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LETTER

FROM

THE SECRETARY OF AGRICULTURE

TRANSMITTING IN RESPONSE TO

S. Res. 175

(SEVENTY-SECOND CONGRESS)

THE REPORT OF THE FOREST SERVICE OF THE
AGRICULTURAL DEPARTMENT ON THE
FOREST PROBLEM OF THE
UNITED STATES

IN TWO VOLUMES

VOLUME I

Index in back of Volume II

[redacted]

March 13 (calendar day, March 30), 1933.—Referred to
the Committee on Printing

UNITED STATES
GOVERNMENT PRINTING OFFICE
168342 WASHINGTON : 1933

73d Congress, 1st Session | SENATE | Document No. 12

A NATIONAL PLAN FOR AMERICAN FORESTRY

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A. P. RUSSELL
FORESTER
SUMTER, S. C.

SENATE RESOLUTION NO. 57

Submitted by MR. COPELAND

IN THE SENATE OF THE UNITED STATES,
March 13 (calendar day, April 4), 1933.

Resolved, That the report of the Department of Agriculture entitled "A National Plan for American Forestry," transmitted to the Senate on March 30, 1933, in response to Senate Resolution 175, Seventy-second Congress, be printed, with illustrations, as a Senate document.

Attest:

EDWIN A. HALSEY,
Secretary.

For sale by the Superintendent of Documents, Washington, D.C.
Price $1.75 per set of 2 volumes.

A. P. RUSSELL
FORESTER
SUMTER, S. C.

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A. P. RUSSELL
FORESTER
SUMTER, S. C.

LETTERS OF TRANSMITTAL

Department of Agriculture,
Washington, March 27, 1933.

The President of the United States Senate.

Sir: I have the honor to submit herewith a report on the forest problem of the United States prepared by the Forest Service of this Department, pursuant to Senate Resolution 175 (72d Cong., 1st sess.), introduced by Senator Royal S. Copeland.

The Department construes the central purpose of the resolution to be a coordinated plan which will insure all of the economic and social benefits which can and should be derived from productive forests by fully utilizing the forest land, and by making all of its timber and other products and its watershed, recreational, and other services available in quantities adequate to meet national requirements.

The main findings of the inquiry made in compliance with the resolution are:

1. That practically all of the major problems of American forestry center in, or have grown out of, private ownership.
2. That one of the major problems of public ownership is that of unmanaged public lands.
3. That there has been a serious lack of balance in constructive efforts to solve the forest problem as between private and public ownership and between the relatively poor and the relatively good land.
4. That the forest problem ranks as one of our major national problems.

The main recommendations, as the only assured means of anything approaching a satisfactory solution of the forest problem, are for:

1. A large extension of public ownership of forest lands, and
2. More intensive management on all publicly owned lands.

The extent to which the major problems of American forestry center in, or have grown out of, private ownership are indicated by the following:

Ninety percent of the total area of devastated and poorly stocked forest land and 95 percent of the current devastation is on privately owned lands.

Forest deterioration, which is far more extensive and hence more serious than devastation, results from cutting without regard for the future productivity of the forest, or from forest fires, or from the two combined. More than 99 percent of such cutting and 98 percent of the area burned annually is on private lands.

The public policy of passing excessive areas of forest land to private ownership and the private cut-out-and-get-out policy has wrecked or seriously reduced the productivity of the land, made it difficult or impossible to pay taxes, and hence has led to tax reversion so large in several forest regions as to constitute virtually a breakdown of private ownership. Stability of tenure is one of the essentials for timber growing.

The overload of forest land and timber in private ownership and the cut-out-and-get-out policy have led to excessively large capital investments in manufacturing plants, high capital charges, pressure to liquidate, overproduction, demoralized prices, waste of the raw product, and large financial losses to the forest industries and chiefly to the lumber industry.

Transient forest industries resulting from the conditions described have caused far-reaching and utterly demoralizing economic and social losses to dependent industries, to local communities, and to entire forest regions. The full extent and far-reaching character of such losses has been but little appreciated.

The problem of balancing the national timber budget centers largely in private ownership because four fifths of the timber-growing land with 90 percent or more of the possible growing capacity is privately owned. The practically universal tendency under private ownership is to reduce the forest capital or growing stock below the point where satisfactory growth is possible. The forest capital of the entire East, for example, where 96 percent of the forest land is still in private ownership, must be increased 2½ times to permit growth adequate to meet national requirements, but the current drain from cutting and losses in the East exceeds growth by nearly 29 billion board feet annually. Furthermore, we must depend upon eastern forest lands for nearly 85 percent of our forest growth.

The most critical factor in balancing the timber budget is the large saw-timber sizes, which take the longest time to grow and which now constitute 70 percent of the drain on our forests. Drain in these sizes exceeds growth by five times. This deficit has been concealed by the remaining supplies of virgin timber. But 80 percent of the remaining saw timber and 95 percent of the old growth is in the far West, and probably not much more than half is accessible and available under present conditions. The privately owned forest capital in the West is being liquidated as rapidly as possible, and if present processes continue, the same kind of a deficit will be created as in the East and the possibilities of full growth will be reduced for many years.

Private ownership of forest or of agricultural land is responsible for practically all of the critical watershed problems of the East and a substantial part of those of the West. The result is unnecessarily destructive floods, causing damages running into scores of millions of dollars and the wasting away in a few years of the soil resource which will require centuries to replace.

The largest and most critical western forest range problem is on privately owned lands where the forage cover has been reduced by half or more over large areas. The eastern problem is almost entirely one of private ownership.

The forest land problem is aggravated by still another growing out of private ownership. More than 50 million acres of agricultural land, originally timbered, have been abandoned because they were never suited for agriculture or because they have reached the submarginal class from erosion or other causes. The land is now idle and available for forestry. The area may become still larger in the future.

From these abandoned agricultural lands have arisen many of the most acute erosion and watershed problems in the East, as well as economic and social maladjustments of first magnitude and similar in character to those resulting from forest devastation and transient forest industries.

The unsolved problem of unmanaged forest lands in public ownership has both Federal and State aspects. The Federal problem lies in the unreserved, unmanaged, overgrazed, and too largely unprotected remnant of the public domain, about 23 million acres of which are forested. The State problem includes the forested portion of Federal grants which have never been given a legal status as State forests and placed under management and the much larger area in various stages of reversion to public ownership because of tax delinquency. Both classes are in a twilight zone. Tax delinquency is creating a new public domain not of forested land but largely, instead, of devastated forest land, and of such size that it promises to be a heavy burden. Few States have legislation that provides for a solution, and still fewer take advantage of the legislation they have.

The unbalanced character of the constructive efforts to solve the forest problem as between private and public ownership and as between relatively poor and relatively good land for timber growing is shown by the fact that nearly 90 percent of the constructive effort as measured by recent expenditures has been made by the Federal and other public agencies, and two thirds of this effort has been concentrated on publicly owned lands.

Private ownership has contributed only about 10 percent, and about half of this has gone into research, much of which is aimed at uniformity of product. Only about 5 percent of the total constructive effort has therefore been made by the owners on 80 percent of the forest land available for timber growing, which has 90 percent or more of the potential growth capacity.

From the timber growing standpoint and disregarding ownership, the concentration of some 60 percent of current expenditures, which totaled nearly $43,500,000 in 1932 on 10 percent or even less of the possible timber production and of around 5 percent of expenditures on 90 percent or more of the possible timber production, is exceedingly poor national economy, regardless of the fact that the present effort on public lands should be strengthened.

The relation of constructive effort to other forest products than timber is similar.

The inquiry makes it more clear than ever before that the solution of our forest problem is one of our major national problems. This is indicated in part by the brief references to findings already made.

But, in addition, the solution is the only means for utilizing our forest and abandoned agricultural land, which constitutes more than one third of the total land area of the continental United States. The only other possible use is for agriculture and the area needed for agriculture has been decreasing.

The solution is the only, or the best, means for supplying wood and other renewable resources. Wood is one of the natural resources on which our civilization has been built.

Under many conditions the forest probably offers the best and cheapest method available for erosion control and stream-flow regulation. One half, or 308 million acres, of the total area of forest is classified as having a major influence on watershed protection and three fourths as having a major or moderate influence. The forest may also be the cheapest and best and in some instances the only means for rebuilding impoverished soils on millions of acres against possible future needs for agriculture.

Already one of the great opportunities for recreation, the forest can, by taking advantage of improving transportation facilities, be made to aid materially in solving the problem of how to use the increasing leisure time of all classes of people. Forest land is the natural and often the only remaining habitat of many forms of wild life, and the same is true of forest waters for fish. Forest ranges can support millions of domestic livestock for at least a part of the year.

The solution is the only means to stable permanent forest industries, with a predepression value including forests of $10,000,000,000 and gross products prior to 1929 of nearly $2,000,000,000. This is also true of industries using other forest resources than timber and of a large group of other industries dependent on both.

The solution will provide an important source of employment for labor at a time when the development of labor-saving machinery makes employment a critical national problem. Our forest land in productive condition and the dependent primary forest industries alone would furnish employment for 2 million men.

The solution offers an important aid in public finance by increasing the amount of taxable property. A $100,000,000 investment in pulp and paper plants in Wisconsin could be permanently supplied by 2 million acres of productive forest.

It offers one important means for maintaining a balanced rural economic and social structure in the parts of the country which will grow timber, by utilizing all of the land productively for the purposes for which it is best suited, maintaining industries in perpetuity, and holding a reasonable part of the population in the country in a healthy, diversified rural life.

Such considerations as these make the forest problem one of the largest which the American people have ever faced, and one of the most urgent now demanding attention.

A satisfactory solution of the forest problem will require the nearest possible approach to national planning. The laissez-faire and avowedly planless policy of private ownership is failing to meet the situtation. The long-time character of forestry itself, the magnitude and cost of the undertaking, and the impossibility of doing immediately everything which must be done emphasizes the desirability of national planning.

Programs for the various activities which make up forestry, such as protection against fire, insects, and disease; extensive and intensive forest practice; provision for watershed protection, recreation, forest wild life, and for the management and utilization of forest ranges have been worked out in as much detail as present information permits and incorporated in the national plan which forms an important part of the report on the Senate resolution. The Department endorses the recommendations for these programs.

The most important recommendations growing out of the inquiry, for a large increase in public ownership and for the intensification of management of publicly owned lands, are based largely on three considerations:

1. The extent to which the major problems of today center in private ownership, and the extent to which private effort on which

we have been placing main dependence is failing to meet national needs, both despite a free hand and substantial if not adequate public aid. Public aid to private owners has in fact been more than twice the expenditures of private owners on their own lands.

2. The lack of any reasonable assurance based on experience that private ownership on the large proportion of the forest lands it now holds can or will carry through the essential, constructive programs, many of which must be of great size. These include placing an additional area of 191 million acres under fire protection and raising the standards on much of the 321 million acres now under protection, planting at least 25 million acres during the next 20 years, raising the area under intensive forest management during the next few decades to at least 70 million and preferably to 100 million acres, and the area under extensive management to at least 279 million and preferably to 339 million.

3. The belief that a greatly enlarged public ownership offers the most effective solution in the public interest and that in the long run it will be much more than self-liquidating in direct and indirect returns.

The Department therefore fully endorses the conclusions reached, that public agencies should acquire 224 million acres of forest land, including a part of the abandoned agricultural land now available, and place it under forest management at the earliest possible date following acquisition. A considerable part of this land has or will come into public ownership anyway by reason of tax delinquency. The States and their local subdivisions should take over as much of this acquisition program as their resources permit. The Federal Government should assume only that part which the States cannot carry. It is believed that the resources of the States will be fully taxed to acquire and manage 90 million acres, leaving 134 million for the Federal Government.

Although at first opposed, the national forest enterprise now has practically universal public approbation. I am convinced that the public program recommended will command equal approval in the future, and that the extension of the national and State forests recommended is as important and as necessary as the creation of the existing national and State forests. The Federal share of the proposed program, including both acquisition and the management of acquired and existing national forests, has, therefore, the unqualified endorsement of the Department.

So far as I can see, nothing can be gained and much will be lost by delay. The contribution to our national land problem will be very large, and it is a contribution which is more and more urgently needed. There should be the opportunity for the large employment of labor in constructive public works. The longer that forest devastation and deterioration continue the higher will be the cost of forest restoration. A high percentage of the initial costs are in the nature of capital investments, for which low-interest long-term loans would be justified. I strongly recommend, therefore, the earliest possible action on the Federal part of the plan.

The plan recommended goes as far as possible in coordinating the effort of all interested agencies. In the acquisition of land it is believed that the soundest principle will be for each public agency to finance its own purchases and to acquire only what it can subsequently afford to manage. The part of the undertaking left to the private owner is believed to be within practical possibilities. A substantial increase in public aid is provided, in which the Federal Government and the States should join forces. Aid to private owners should not, however, go beyond the public interest. The States and their local subdivisions are encouraged to take on as much of the remainder of the undertaking as they can and will. This will leave for the Federal Government only what neither private owners nor the States can carry, and beyond that what is clearly within the national interest. The resolution stresses aid to the States. A detailed examination of the program proposed will show that the very liberal Federal contribution to the whole plan in the form of aid to private owners and otherwise constitutes in the last analysis aid to the States which would otherwise have to carry the entire burden.

Respectfully,

H. A. Wallace,
Secretary.
R. G. Tugwell,
Assistant Secretary.

United States Department of Agriculture,
Forest Service,
Washington, March 24, 1933.

The Secretary of Agriculture.

Dear Mr. Secretary: I am transmitting herewith a report on Senate Resolution 175. In many respects it represents the most comprehensive and exhaustive survey yet made of the forestry situation in the United States. It goes to the full limit of possibility with the staff at our disposal and the data which could be collected and utilized in the time available.

I have been in close touch with the work from the preparation of the initial plans and have personally reviewed the entire discussion which supports the conclusions reached. In my judgment the time has come for another great forward step in American forestry, and a major portion of the step should be the public assumption of a much larger share of the enterprise. If the recommendations on this phase of the problem can be carried out and carried out promptly, it will mean the greatest advance since the creation of the existing national forests, which has been the largest and most spectacular development to date. It will be an advance of even greater magnitude. The need is also greater. This, however, is only one part of a coordinated national plan of which I earnestly recommend your approval for submission to the Senate.

A large number of Forest Service employees have participated in the preparation of this report. Lasting credit is due to Earle H. Clapp, Assistant Forester in charge of research, who made the initial plans, and by personally directing the project throughout has made possible this outstanding contribution to forestry. We have felt free to draw upon the services of other bureaus in this and other Departments where the nature of the subject justified, and I desire to make full acknowledgement of the help received.

Very sincerely yours,

R. Y. Stuart, *Forester.*

A NATIONAL PLAN FOR AMERICAN FORESTRY

MAJOR PROBLEMS AND THE NEXT BIG STEP IN AMERICAN FORESTRY[1]

A SUMMARY OF THE REPORT ON SENATE RESOLUTION 175

By Earle H. Clapp, In Charge Branch of Research

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[1] This statement embodies the findings of all the sections of this report which follow. In a very real sense it is an expression of the findings and the conclusions reached by a large group of men. Acknowledgment is made to this entire group, which includes the authors of the sections and a much larger number of Forest Service employees and those of other organizations who aided in the collection of the data and their compilation and preparation for publication. Because references to sections would have to be exceedingly numerous, none whatever are made.

THE PROGRESS OF FORESTRY IN THE UNITED STATES

The American people have reason to be proud of the progress of forestry in the United States. In its modern phase this progress has been made largely since 1900, although it began in 1876 with the appointment of one man in the Federal Department of Agriculture.

THE FEDERAL CONTRIBUTION

To this progress the Federal Government, the States and their political subdivisions, various quasi-public agencies, and private owners, have contributed.

THE NATIONAL FORESTS

The national forest enterprise has been the most conspicuous single effort in the development of American forestry.

The great significance of the national forest enterprise lies in the fact that it has been a trial on a grand scale of Federal public administration of a great natural resource in the public interest. This has been a radical departure from the traditional American policy of private ownership of natural resources and their exploitation for private profit.

The national forests now exceed 161 million acres. The 140 million in the continental United States contain nearly one sixth of our commercial forest land or that suitable for timber growing, and 30 percent of our noncommercial forest land or that chiefly valuable for such other purposes as watershed protection and grazing. They contain one third of the remaining saw timber.

Virtually all of the major streams west of the Great Plains head in them. All of the lands purchased in the East are on the watersheds of navigable streams.

They contain 83 million acres of range lands in the West, or 12 percent of the total western range area.

Substantial or large parts of practically all the major mountain ranges in the United States fall within the national forests, which constitute the great playgrounds and include much of the most beautiful scenery of the country.

They constitute our great public hunting grounds, 75 percent of the range of the big game animals of the West, and much of the western fur-bearing area. They include 60,000 miles of streams and many thousands of lakes suitable for fish.

For all of these interrelated resources the soil is the basic resource.

Of hardly less significance in the national forest enterprise than the trial of public administration of a natural resource has been the adoption of far-reaching plans to insure both maximum use and perpetuity and the use of each forest resource in relation to all.

All of the 74,680,000 acres of commercial forest is under timber management, 21 million acres have detailed sustained yield management plans, and 29 million acres more general plans. All of the 1,250 million board feet cut annually from 125,000 acres is under silviculture which will perpetuate the forest and maintain the forest capital. About 25,000 acres are now being planted annually. The sustained yield capacity of the forest is being steadily increased.

Range management plans have been prepared or are in preparation for the entire national forest area utilized for grazing; fairly intensive plans for 33 million acres. National forest ranges now support 8 million head of cattle, horses, sheep, and other domestic livestock.

The full services which the forest and range cover can render in watershed protection are gradually being assured by the management of timber and forage and their protection against fire.

The national forests are now visited each year by more than 30 million people seeking recreation. Management plans provide for the gradual development of camping grounds, for the leasing of summer home sites, and for other needed facilities. More than 50 areas containing about 9 million acres have already been set aside to prevent needless impairment of pioneer conditions.

Under protection wild life is being gradually increased, despite the fact that 100,000 big game animals are being killed annually. As fast as the possibility of management is reached plans are prepared and put into effect.

Protection against fire is necessary in the management of all forest resources. In spite of a rapid increase in human use, the size of the area burned in the average year has been reduced from about 1,350,000 acres to about 500,000 acres between 1910–15 and 1920–25. The ratio of actual to allowable burn has been brought to 1.07 to 1. On all but 30 of the 95 million acres requiring protection a satisfactory ratio has been reached. An important factor in this improvement has been the development of detailed plans for fire protection.

In normal years business for the entire national forest area includes, in part, more than 80,000 individual business transactions, some of great size; the administration of all use; the control of some 8,100 forest fires; the planting of 25,000 acres; the planning and construction of nearly 4,000 miles of roads; of more than 8,500 miles of trail; the purchase of 450,000 acres of forest land. Aggregate expenditures in 1930 reached more than $11,500,000 for administration and protection and $6,000,000 for capital investments. Receipts were nearly $7,000,000.

A competent staff has been developed, the stability of which is assured by civil-service protection, a stability common to all Federal agencies engaged in forest activities.

Opposition to such a radical departure as the national-forest enterprise was inevitable. Violent to begin with and still sporadically recurrent, it is gradually decreasing. In general the national forest concept of Federal administration in the public interest of a great national resource under a policy of integrated sustained yield management has become an accepted fact in public opinion. Although facing many unsolved problems of administration, resource management, and protection, the national forests are an outstanding example of land administration and of public administration of any sort. Forty years' trial has built up the resource itself, despite continuously enlarging use. The national forests have become a vital part in the existence of local communities and even of whole States, the source of being of many industries, and the opportunity for the employment of labor. They are already showing something of the magnitude of the economic and social services which the sustained yield forest can render, but the full possibilities are far in the future.

NATIONAL PARKS

The Federal contribution to American forest land use has also included the creation and administration of the national parks. Their 4½ million acres of forest enhance many of the finest and most unique scenic areas in the United States.

Although their primary service is inspirational and the commercial utilization of timber and forage is not permitted, much of the national park forest affords valuable watershed protection.

Within their own specialized field of land use the national parks have pioneered and have developed highly intensive plans and management and a personnel for this specialized work. The Yellowstone, established in 1872, was the earliest venture of this kind.

THE INDIAN FORESTS

Paralleling the national forest concept of public administration of forest land in the general public interest is the Federal administration of the Indian forests for the Indian wards of the Government. Indian reservations include about 7½ million acres of commercial forest land.

Detailed sustained-yield-timber-management plans are in effect on about 5 million acres, and all timber is being cut in compliance with sound silvicultural principles. General range management plans have been prepared for 12 and fairly intensive plans for 3½ million acres, and the administration of range use is being rapidly perfected. Fire-protection standards are being raised, and the protection of watersheds is gradually improving.

FEDERAL AID

In addition to the administration of nationally owned and Indian lands the Federal contribution to American forestry takes the form of financial aid to the States and private owners of forest land.

The national interest in making forest land productive would in itself justify such aid, but it is also an effort to stimulate both State and private effort.

An annual contribution of about $1,575,000 for fire protection in 1932 is now helping to make possible the protection of nearly 230 million acres in 40 States and the reduction of the area burned to less than 2 percent annually, in contrast with nearly 20 percent on unprotected lands.

About $80,000 aids in the annual distribution of 25 million forest tree seedlings at low cost in 38 States; about $70,000 in the assistance of nearly 10,000 farmers in woodland management. Annual appropriations and the income from land-grant endowments totaling about $3,500,000 aid in the support of colleges of agriculture in nearly 40 States, in 16 of which instruction in forestry leading to a degree is given. Only a small part of an annual contribution of $4,320,000 to State agricultural experiment stations is used for forest research, but may help to release a larger sum of State appropriations for this purpose.

Large Federal land grants to the States, although not so intended, have been the foundation for Western State forests and in part those of the Lake States.

Indirectly the annual Federal-aid road contribution, which reached nearly $135,000,000 in 1931, has had important but not measurable value in improving transportation facilities for forest products, and hence in creating more favorable conditions for timber growing.

The main results of Federal financial aid have been—

The stimulation of State effort. It has been an important factor in the establishment of 12 State forestry departments, the initiation of fire protection of private land in 17 States, the enlargement of the protected area of State and private lands by nearly four times, the initiation of nursery stock distribution in at least 12 States, of farm wood-lot extension in 33 States and 2 territories. State expenditures for aid have increased from possibly $500,000 in 1911 to nearly $5,500,000 in 1932.

The stimulation of private effort. Private expenditures for organized fire protection have grown from about $55,000 to $1,000,000 between 1911 and 1932. Private owners probably supplement the organized effort with the expenditure of an additional $300,000. The expansion in other phases of private effort have probably not been in the same proportion.

RESEARCH

Forest research in the Department of Agriculture is based upon the Federal responsibility for work on national, interstate, or regional, and international problems, and also local problems where the administration of Federally owned or managed forests is involved. It has important aid aspects.

A national plan designed to meet these Federal obligations has resulted in the establishment and concentration of the work largely at a series of regional forest experiment stations and a national forest products laboratory.

Practically the entire field of forestry is being covered, including the establishment, growing, and management of forests; their protection against fire, insects, and diseases; the management and utilization of forest ranges; erosion control and stream-flow regulation; the utilization of forest products; forest wild life; and forest economics. A scientific basis for the practice of forestry and the economic basis for national and regional forest land planning adapted to American species, conditions, and requirements are gradually being developed.

Expenditures for 1932 total about $3,000,000.

THE STATE CONTRIBUTION

STATE ORGANIZATIONS

Forty-two States now have legal provision for work in forestry and in all but five an organization has been set up. This marks progress since the beginning by California, New York, Ohio, and Colorado in 1885.

Great differences in regional conditions and problems, in the aggressiveness of leaders and opponents, in public opinion and the attitude of the press, have caused State activities to vary within wide limits and except for Federal leadership the variation would have been much greater.

STATE AID

All of the States except Arizona, Missouri, and South Dakota now give some or all of their forest landowners more or less aid. Expenditures for this purpose reached nearly $5,500,000 in 1932.

Aid, and more specifically in fire control, is in fact the chief job of nearly all the State organizations. Expenditures for fire reach nearly 60 percent of the total for all aid. Those for fire, disease, and insect control reach nearly 90 percent, but aid is also extended in planting, research, and advice to forest landowners, mainly farmers.

More than 80 percent of the expenditures for aid are concentrated in the New England, Middle Atlantic, and Lake States.

The States maintain all but 3 of the 25 forest schools of collegiate grade in the country on which they are expending about $925,000 annually. They are training more than 95 percent of the professional foresters.

STATE FORESTS AND PARKS

The entire area of State forests, now nearly 4½ million acres, is under some degree of administration, mainly fire protection. About 1 million acres are under timber management plans. Nearly 5½ million, including some State land not having formal legal status as State forests, are managed with reference to future timber production. About 75 percent of the total area of State forests is in Pennsylvania, Minnesota, and Michigan.

State parks total nearly 2,700,000 acres, four fifths in New York under a high degree of administration for recreational use.

State-owned lands not in either formally designated State forests or parks aggregate nearly 6,150,000 acres, more than half in Washington, Minnesota, and Idaho. Most are under protection; in some the cutting of timber is regulated. Since these lands have no clearly defined legal status as either forests or parks, the area as a whole is in a twilight zone.

Nearly 90 percent of the organized and formally designated State forests and parks are in the Northern, Middle Atlantic, and Lake States, and more than 85 percent of all State-owned forest land is in the Atlantic and Lake States and the Pacific Northwest.

The holdings of the wealthy Middle Atlantic and New England States have been acquired largely by purchase, those of the Lake States through tax delinquency and Federal grants, and those of the Northwest from Federal grants, under stimulus of the national forests. Elsewhere State forests are practically nonexistant.

An additional 2¼ million acres is definitely in process of acquisition for State forests, nine tenths in Minnesota and Wisconsin. A very large but unknown area is reverting to State ownership through tax delinquency. Michigan, New York within the forest-preserve counties, Virginia, and South Carolina have made legal provision for the consolidation of suitable delinquent lands into State forests. The New York 20-year program for the acquisition of submarginal agricultural lands and their reforestation is unique in its anticipation of this problem.

In general the creation and administration of State forests and parks have been given secondary consideration. They are more difficult to handle than fire control, the principal State activity.

Much greater emphasis and even a realignment of personnel will be required if they are to occupy the place they can and should. One State—New York—gives the head of its forestry work the protection of civil-service standing by law, and six give this protection to officers in lower positions.

State expenditures for all forest activities totaled about $9,000,000 in 1932.

PUBLIC REGULATION

State effort in public regulation has been mainly in legislation dealing with the use of fire and its enforcement. Nearly all States have such fire legislation, a few are enforcing it effectively, and many make some attempt at enforcement.

OTHER PUBLIC FORESTS AND PARKS

Nearly 1,000 county, municipal, and town forests now aggregate about 1 million acres.

County forests of slightly more than half the total area have significance in Wisconsin chiefly, and in New York. Two fifths of the Wisconsin forests, originating in tax delinquency, are under administration.

Probably half the number and four fifths of the area of all municipal and town forests protect municipal water supplies and are under intensive protection and administration for this purpose. Many have recreational significance.

In 29 of the 48 States tax-delinquent lands revert to the counties or towns. The area of forest land already delinquent has reached many millions of acres. Some provision for consolidation and administration as county forests or for transfer to the State or for administration by the State has been made by law in Wisconsin, Oregon, and Minnesota.

Total expenditures by the political subdivisions of States in the field of forestry were about $1,650,000 in 1932.

THE PRIVATE OWNER'S CONTRIBUTION

Nearly 400 million acres, or practically 80 percent of the commercial forest land in the United States, is in private ownership, and 127 million acres of this is in farm woodlands.

By far the largest conscious contribution of the private owner to American timber production is in fire protection. Toward the cost of organized protection on about 225 million acres, as already indicated, the owners contributed approximately $1,000,000 in 1932, or about one sixth of total expenditures. For the 2 preceding years the contribution was between one fifth and one fourth. Nearly 20 million acres more are protected by the owners themselves at a cost of about $300,000.

Organized sustained-yield management for areas exceeding 1,000 acres is believed to be in effect on about 2.3 million acres; and measures other than fire protection to prolong productivity, on more than 15½ million acres. The extension over the entire farm-woodland area of fragmentary data from New England indicates active efforts to promote tree growth on about 4 million acres. Private owners have planted about 1.2 million acres and are adding to this at the rate of about 50,000 acres annually.

Great credit is due to the group of private owners who have pioneered in forest management on their own lands.

Research expenditures by private owners reach about $2,500,000 annually. Pulp and paper manufacturers are responsible for four fifths of the total and concentrate their efforts largely on manufacturing technique to insure uniformity of product. It may be much more than a coincidence that the wood products on which most research is being done are also those on which the use is increasing rapidly. Practically the entire expenditure for research deals with the utilization of forest products.

Total expenditures by private owners probably therefore total somewhat over $5,000,000, half of which is for research.

THE CONTRIBUTIONS OF OTHER AGENCIES

Scientific organizations and forestry and conservation associations have exerted an important influence as leaders in the development of public-forest policies and the awakening of public sentiment.

The American Association for the Advancement of Science initiated the movement which started forestry as an organized and permanent activity in the United States Department of Agriculture in 1876. This association was active also in obtaining the passage of the act of 1891 which authorized the setting aside of the "forest reserves" from the public domain.

A committee of the National Academy of Sciences formulated the recommendation which was the basis for the act of 1897 providing for the administration of the "forest reserves."

The American Forestry Association since its organization in 1875, and the American Tree Association since 1922, have played a very large part in arousing and organizing public sentiment in support of Federal and State legislation. So also have numerous State forestry associations, among which the Minnesota, Colorado, Pennsylvania, and Massachusetts associations and several in southern California are or have been notable. Among other activities the Society for the Protection of New Hampshire Forests has for years aggressively supported Federal acquisition of forest land. Regional associations, including the Western Forestry and Conservation Association, the Southern, and more recently the Central States Forestry Congresses have performed similar services.

Several endowed research institutions include forest research of a fundamental character in their field of work and are now expending about $230,000 annually.

The endowed forest schools, although limited in number, have exercised a pronounced leadership in both education and the national development of forestry.

PROGRESS IN SUM

Progress in American forestry to date has put approximately 110 million acres under conscious effort other than fire protection to prolong the productivity of the forest for timber growing. Perhaps 30 million acres of the total is under fairly intensive timber-management plans and twice as much more under more general plans, the outstanding feature of which is sustained yield.

Approximately 10 million acres are cut over annually, and of this perhaps one twentieth is consciously cut under more or less intensive silvicultural principles. The total area planted is about 1,900,000 acres and is now being increased by 153,000 acres a year.

Out of a total area of 334 million acres of forest lands grazed some kind of management plans are in effect or are under preparation for about 85 million. For perhaps 40 million the plans are intensive.

About 8 million acres are under intensive management for recreational purposes, not including the areas within the national forests.

Protection of forest wild life on the national forests and parks and in several of the States, particularly in the Northeast, has permitted game to increase materially in numbers during the last few years. Management plans are a development of the last decade. Fish have been introduced into forest waters in which they did not previously occur. Material progress has been made in the artificial propagation of fish and the development of fish-hatchery technique.

More or less intensively organized fire protection, at an annual cost in 1932 of $14,475,000, has been put into effect on a total of 321 million acres, of which about 290 million is commercial forest land.

Forest insect control has been developed for bark beetles in the West, and gypsy and brown-tail moths in the East. Annual expenditures for control by all agencies on some 80 million acres is estimated at $2,100,000.

Organized control of forest tree diseases is largely confined to the white pine blister rust on an area of some 10 or 12 million acres. This, with other small eradication jobs, is done at a cost of about $1,000,000 annually.

Research by all agencies now covers practically the entire field of forestry and called for an expenditure of about $6,315,000 in 1932.

The first college giving instruction leading to a professional degree in forestry was established in 1898. There are now 24. The number of trained professional foresters has reached a total of about 4,500 and is being increased by about 400 annually.

Total expenditures in 1932 by all agencies in the entire field of forestry were about $43,475,000 (fig. 1). To this the Federal Government contributed about $26,965,000, the States and their subdivisions $10,650,000, private owners $5,060,000, and quasi-public agencies $800,000. The expenditure of public agencies were, therefore, nearly 90 percent of the total.

Public regulation of private lands, centering mainly in the use of fire, has been gradually building up in legislative provisions in many States. Enforcement varies from States in which it is thoroughly effective to those in which nothing is attempted. A part of the value of the fire legislation has been in the reduction of public carelessness with fire on public forests.

Public aid designed both to meet public obligations and interest and to stimulate private ownership began as early as 1885 and has developed much more rapidly under the stimulus of Federal legislation, particularly that of 1911 and 1924.

The greatest contribution of public aid to private effort has been in putting under fire protection half of the privately owned forest land needing it. In various forms it is partly responsible at least for stimulating other measures to insure productivity on about 25 million acres of private land, including the planting of 1.2 million acres.

Federal aid has been a factor of primary importance in initiating or strengthening forestry organizations in practically all of the 42 States in which one now exists. Aid to private owners is the chief activity of nearly all State organizations.

The most conspicuous contribution of private owners has been in fire protection, to which they are devoting more than one fifth of their current expenditures, approximately $5,050,000 for 1932. Considerably less than half of the $2,500,000 expenditure for research is designed to add to basic knowledge of forest products.

The most spectacular advance in American forestry has been the building up of the national forests from the public domain, which culminated in 1910 with a gross area of nearly 195 million acres.

Since that time the total area of public forests has changed but little, despite the purchase of 4,727,680 acres and other enlargements for the national forests and the gradual building up of State forests. The total net area of all public forests, including interspersed nontimbered lands, is now about 175 million acres.

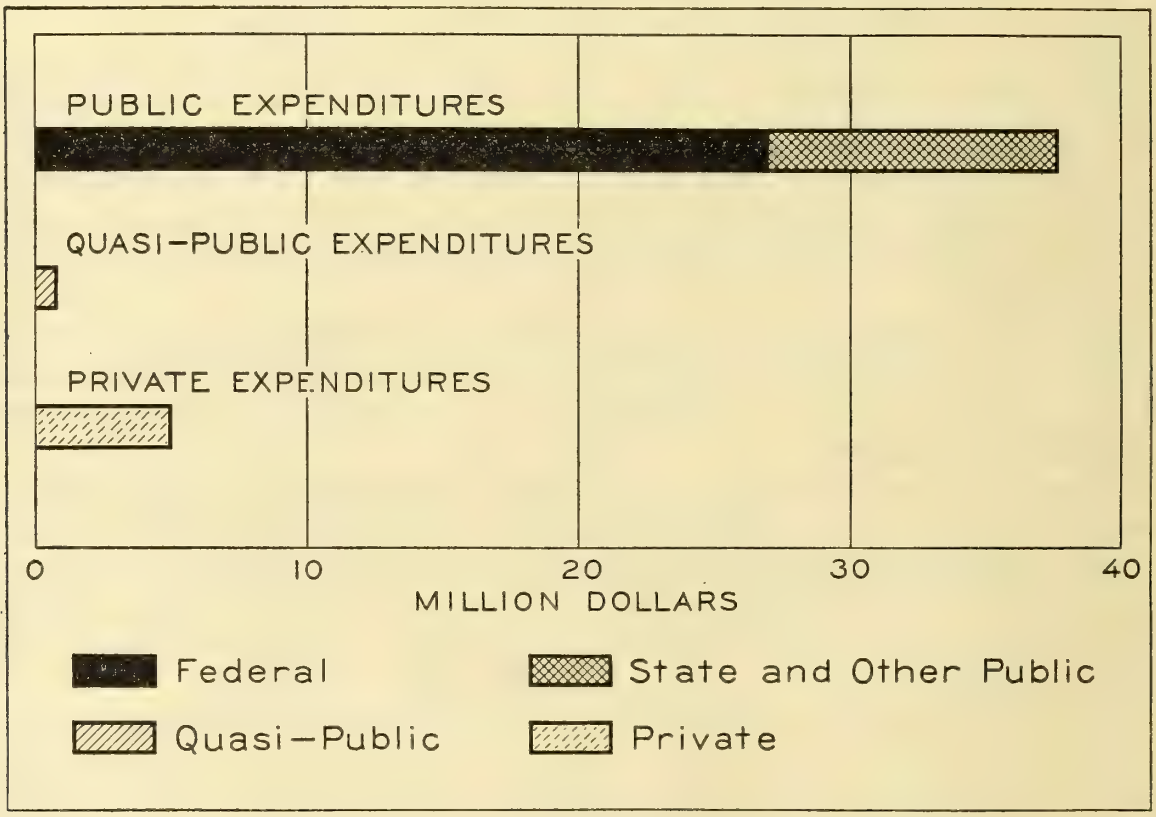

FIGURE 1.—The most significant features in the American 1932 bill for forestry were its total of nearly $43,500,000, and the public contribution of well toward 90 percent.

The period subsequent to 1910 in public administration has largely been devoted to a consolidation of gains. Practically the entire area has been put under more or less intensive sustained-yield management plans for timber, ranges, watershed protection, recreational and other use, and protection against fire. Methods of administration have been developed and perfected. While the need for improvement in technical management and business administration will continue for years to come, much of the most difficult pioneering period has been passed. Public opinion has in general been won over from violent opposition to aggressive support.

If the public need warrants such action, American forestry is now ready for another great advance.

THE MAJOR FOREST PROBLEMS

Despite some reason for gratification in past accomplishments, the American people have no reason to be proud of what still remains to be done to put forestry on a satisfactory footing in the United States.

What is still needed falls logically into a group of major forest problems. Some of these problems have to do with the productive use of land as influenced by ownership and management. Others center in timber, watershed influences, and the other chief products and services of the land. Another deals with the knowledge which must be available for the solution of the problems.

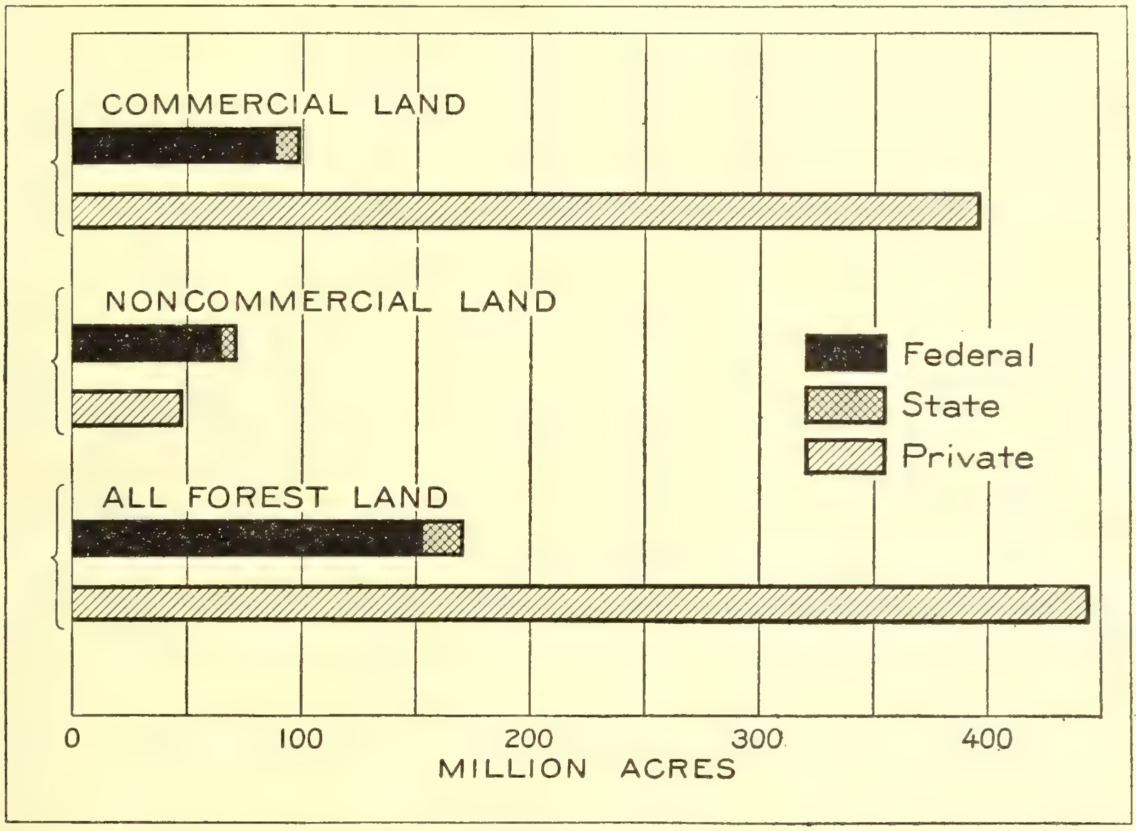

FIGURE 2.—Ownership of four fifths of the commercial or timber-growing land has given the private owner the opportunity to dominate American forestry for better or worse, an opportunity made even more favorable by the quality of the land. "All forest land" includes some reserved areas.

THE PROBLEM OF PRIVATELY OWNED FOREST LANDS

As already indicated, nearly 400 million acres of commercial forest land is in private ownership, 270 in industrial holdings and 127 millions in farm woodlands.

IT IS THE MOST IMPORTANT TYPE OF OWNERSHIP

Private ownership is by far the most important class because of its great area and also because it includes the great bulk (fig. 2) of the most highly productive, the most accessible, and most easily logged forest land in the country. Still further, nearly 60 percent of the most accessible remaining saw timber is on private lands. More than half of the remaining saw timber is industrially owned.

IT IS LARGELY RESPONSIBLE FOR FOREST DEVASTATION AND DETERIORATION

Of the 83 million acres of devastated or poorly stocked forest land, 74 million, or nine tenths (see fig. 3) is privately owned, and an appreciable part of the remainder reached this condition before coming into public ownership or as a direct result of private operations and ownership.

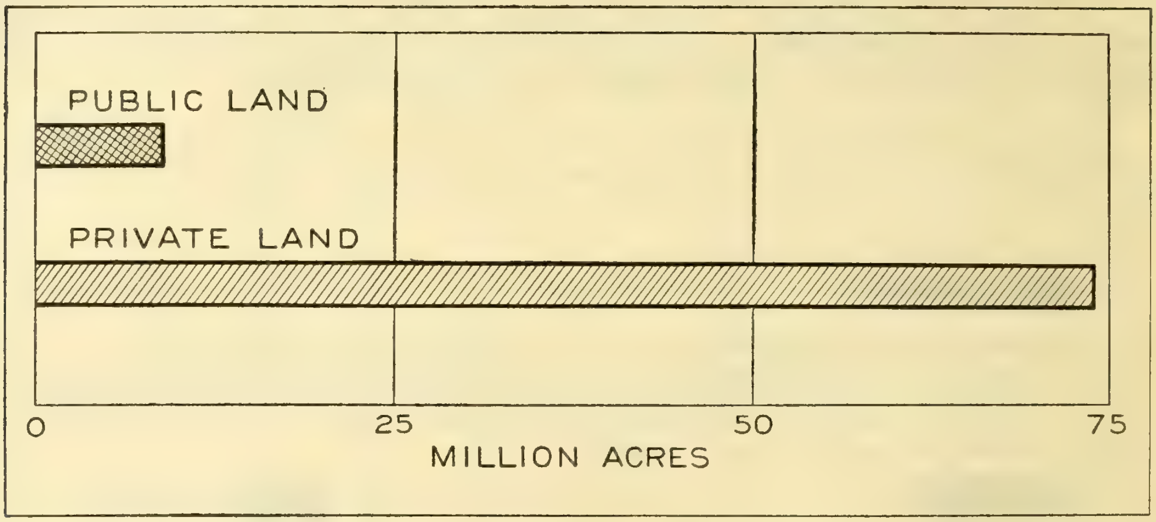

FIGURE 3.—The large proportion of the area of devastated or poorly-stocked forest land in the lower bar does not tell the full tale of responsibility, since private ownership must also answer for a part of the 10 percent now publicly held.

Of the 850,000 acres devastated each year about 95 percent are in private ownership, as shown in figure 4.

At least 36 million acres of forest are being deteriorated annually, primarily as a result of poor silvicultural practice and unsatisfactory fire protection.

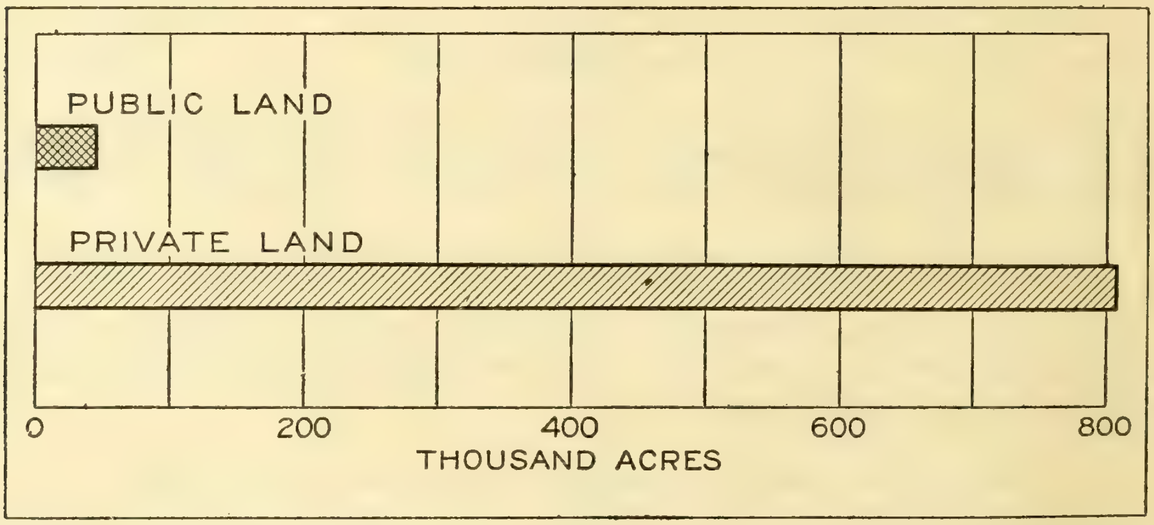

FIGURE 4.—The area of forest land devastated annually. While the current annual rate may be offset in part or altogether by the return of other lands to productivity, the long delay is a heavy drag on the forestry enterprise for which private ownership is chiefly responsible.

The extent to which private ownership is responsible is shown by the fact that more than 98 percent of the 10 million acres cut over each year is privately owned, that fully 95 percent of the private cutting is probably made without any conscious regard to the future productivity of the forest, and that nearly all of the cutting on publicly owned forests is designed to perpetuate the forest. Figure 5 shows these relationships.

It is shown further by the fact that nearly all of the 191 million acres of forest land needing but not given protection is in private ownershir

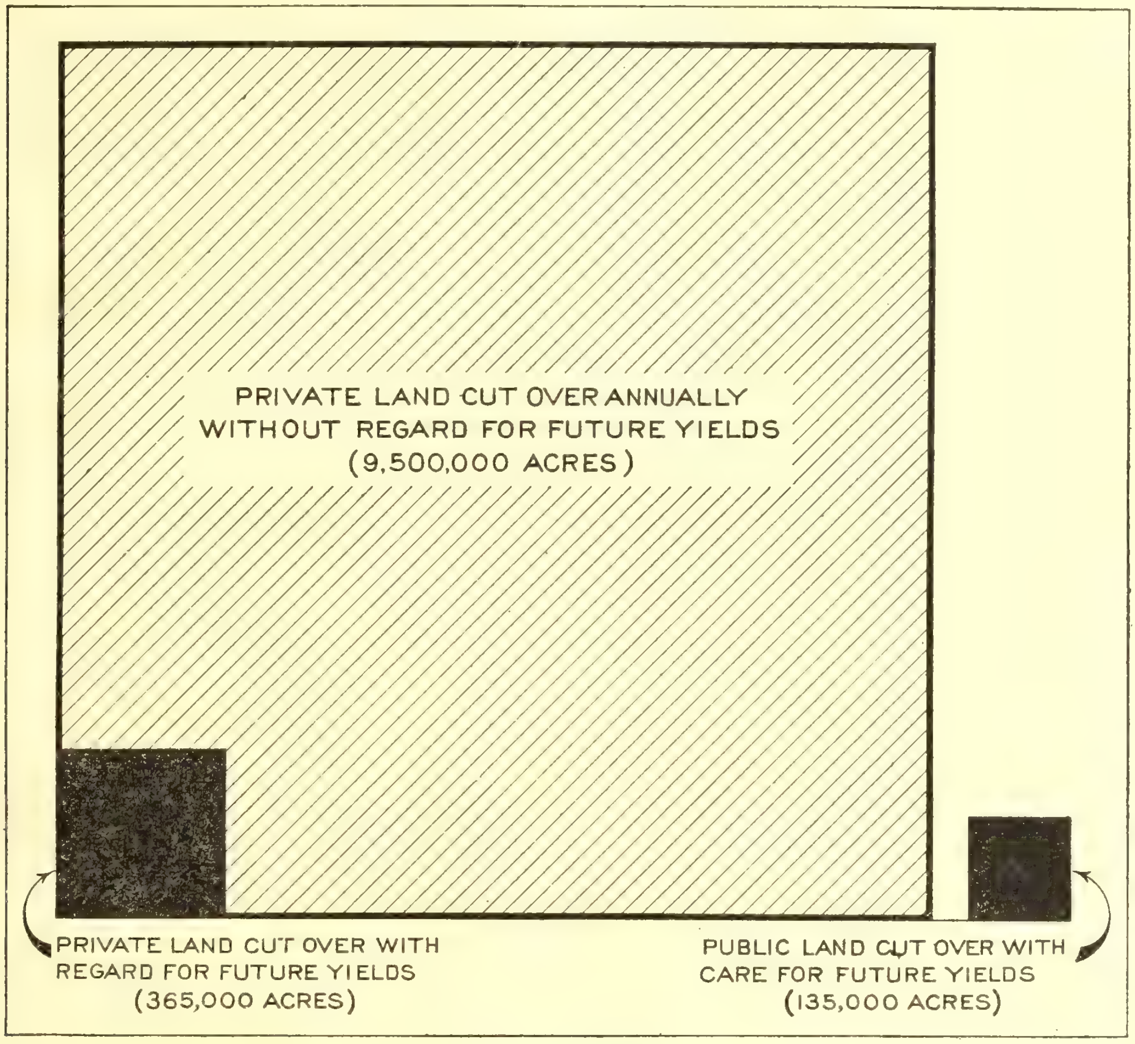

FIGURE 5.—The annual cut, public and private. The large area of private land cut over each year without conscious effort to promote forest growth accounts in part for the 808,000 acres of private land devastated annually and the much larger area deteriorated. Practically all public land is cut with the perpetuation of the forest in view.

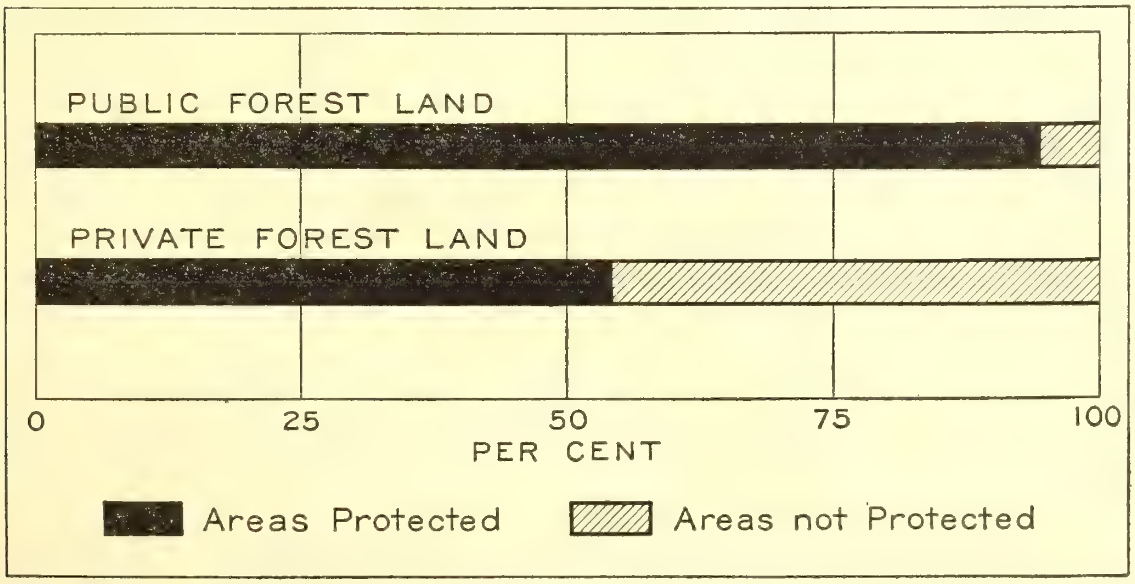

FIGURE 6.—Absence of protection on nearly half of the private lands needing it is one of the main factors in the excessive contribution of private ownership to forest devastation and deterioration.

(fig. 6) and that at least 41 million acres, or about 98 percent of the area burned annually during the last few years, is privately owned (fig. 7).

It is still further shown by the depletion of the forest capital or growing stock of the forests of the entire East, 96 percent of which are still in private ownership and practically all of which reached their present condition in private hands. Forest capital is as necessary to high production of desirable products in timber growing as financial capital is to the development of industry. In order to raise growth to the level of current requirements the growing stock must first be increased nearly 2½ times.

IT IS THE MOST UNSTABLE FORM OF FOREST-LAND OWNERSHIP

Because of the long time required to grow forest crops and the necessity for long-time planning and continuity of policy, stable land ownership is a sine qua non to the practice of forestry.

The instability of private ownership is evidenced by the fact that about 25 million acres of forest land, largely industrial, is now tax delinquent in three regions alone, the Lake, Southern, and Pacific Coast States, that the area for the entire country is much larger, and that the actual total is largely masked by the form of State laws and the character of their administration.

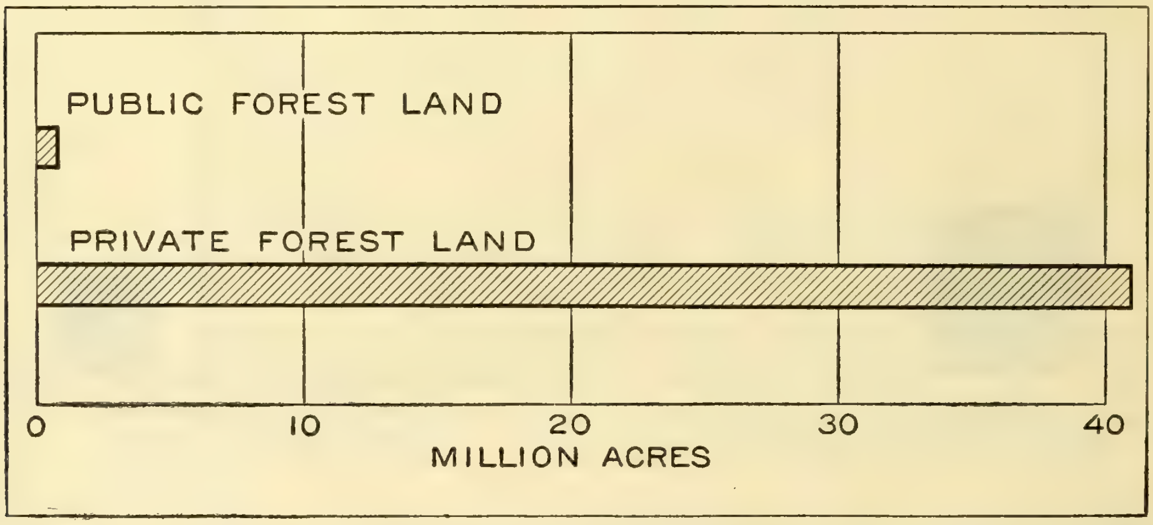

FIGURE 7.—Area of forest land burned annually. Protection of only 54 percent of the area needing it helps to explain the responsibility of private ownership for 98 percent of the area of forest land burned over annually in the United States.

Delinquency long existant has been greatly accentuated by the depression and promises to become larger. More than one third of the forest land in the Lake States is already virtually abandoned, and half promises to be in involuntary public ownership in 10 years.

The instability of private ownership is also evidenced by donations of land to public agencies or offers of donations in large blocks and by offers of exchange and of sale at bargain prices.

A new public domain of great magnitude is being created, before the problem of the existing public domain has been solved. It is no exaggeration to say that there is virtually a break-down of private forest-land ownership.

The cause lies in the public policy of passing excessive areas to private ownership, in the cut-out-and-get-out policy which has wrecked the productivity of the land, and in the resulting inability of owners to pay taxes on nonproductive lands.

IT IS RESPONSIBLE FOR SERIOUS ECONOMIC DIFFICULTIES IN THE FOREST INDUSTRIES

The economic difficulties of the forest industries have not been studied in connection with Senate Resolution 175. The time has not been available, and the Timber Conservation Board was created primarily to cover this ground. No survey of the forest situation in the United States can, however, be complete without reference to them. The difficulties of the lumber industry, which is by far the largest of the forest industries, are undoubtedly the most critical.

The following brief and incomplete résumé is based in part on statements made by representatives of the industry to the Timber Conservation Board and so far made public. All of the statements indicate that the overload of forest land and timber is the basic cause.

The most critical example is probably in the west coast industry, where the investment in nearly 350 billion feet of standing timber is placed at slightly more than $500,000,000. Excessive land and timber holdings in the west coast industry are in part responsible for excessive capital investments in logging improvements and equipment, manufacturing plants, and possibly also working capital, which together add about $335,000,000 to the investment for land and timber.

The resulting fixed and largely inescapable capital charges on the largest annual cut of west coast timber so far made, including interest on indebtedness, taxes, fire protection, and insurance, total $2.983 per M board feet.

Excess manufacturing capacity is shown by West Coast Lumber Association surveys. The installed normal operating capacity was slightly in excess of 14 billion board feet annually. In 1928, 72 percent of this capacity was utilized; in 1929, 73 percent; and in 1930, 54 percent. Plant capacity for the entire country is undoubtedly far more in excess of needs than that shown for the west coast industry.

Overproduction, also cited as one of the most serious problems of the lumber industry, grows in part out of an overload of stumpage and forest land, the consequent financial pressure to liquidate, the development of excessive plant capacity, and the burden of high and largely fixed and inescapable capital costs. Manufacturers have accordingly believed that they would lose less money by running than by shutting down. Uneconomic manufacture, overproduction, and demoralized prices have been the inevitable outcome.

The overload of forest land and timber is also responsible in part for wasteful utilization. A Forest Service survey in the Douglas fir region indicates waste of over 6 million cords of sound wood resulting from logging operations annually. It includes 1.7 billion board feet of material suitable for conversion into lumber, or nearly one sixth of the 1926 cut.

The cause of such waste is overproduction, which leads to "skimming the cream" of raw material. And overproduction goes back in large part to an overload of forest land and stumpage. West coast overproduction and the resulting low lumber prices have, for the time being, handicapped the efforts of owners who have desired to grow timber on their own lands in all of the important forest regions of the East which can be reached by water shipments of lumber at low freight rates.

The underlying cause of the difficulties of the forest industries and particularly the lumber industry, which may be most acute on the west coast, is only in part the overload of forest land and timber. The cut-out-and-get-out policy which has been followed almost universally is also a primary cause.

Sustained yield management would in many cases have required smaller plant capacity, lower investments, and hence carrying charges and capital costs. It would have resulted in lower operating costs from leaving unprofitable timber in the forest to grow, and higher returns from a larger percentage of high-grade material. It might also have resulted in curtailed production. The residual value of a growing forest would have been high as compared with bare land. In brief, devastation has resulted in losses which might have been profits under sustained yield management.

The entire difficulty is merely another phase of the larger problem of private ownership.

IT IS RESPONSIBLE FOR SERIOUS ECONOMIC AND SOCIAL LOSSES TO THE PUBLIC

The economic and social losses to the public extend far beyond the forest industries themselves.

Dependent industries soon succumb after the departure of the forest industries, the tax base is reduced, and local rates must be higher on the remaining property. Tax receipts of local political units fall and many become bankrupt. Outside contributions for local governmental activities become necessary. The standards of community life in schools, churches, roads, etc., are lowered. The population necessarily becomes shifting and labor transient. All possibility of a balanced economic and social structure to which productive forest land and permanent forest industries should contribute is lost for many years.

IT HAS FALLEN FAR BEHIND PUBLIC OWNERSHIP IN MANAGEMENT AND ADMINISTRATION

Practically the entire cut on publicly owned forest land is now made with provision for the renewal of the forest (fig. 5), but probably less than 5 percent of that on privately owned land. The cut on privately owned land is more than 70 times larger.

Although the area of publicly owned commercial forest land is only one fourth that of private, 10 times as much public land is being managed under intensive sustained yield timber management plans and about 4 times as much with conscious effort to prolong productivity (figs. 8 and 9).

One hundred and two million acres of the western forest ranges are in public and 42 in private ownership. The area of public ranges under some kind of management plans is about 16 times, and that under fairly intensive management plans about 12 times those in private ownership (fig. 10).

The area of publicly owned land now being planted is about twice that privately owned.

A little over half of the privately owned land needing protection against fire is under organized protection, but with a public contribution of five sixths of the cost. Practically all of the publicly owned forest needing it receives some protection. The ratio of actual to allowable burn on private lands is about 11 to 1, that on the largest area of public lands—the national forests—is about 1.07 to 1.

While about 1.25 billion board feet are being cut from the national forests, which include 75 percent of the publicly owned commercial forest land, the possible sustained yield cut has been raised steadily.

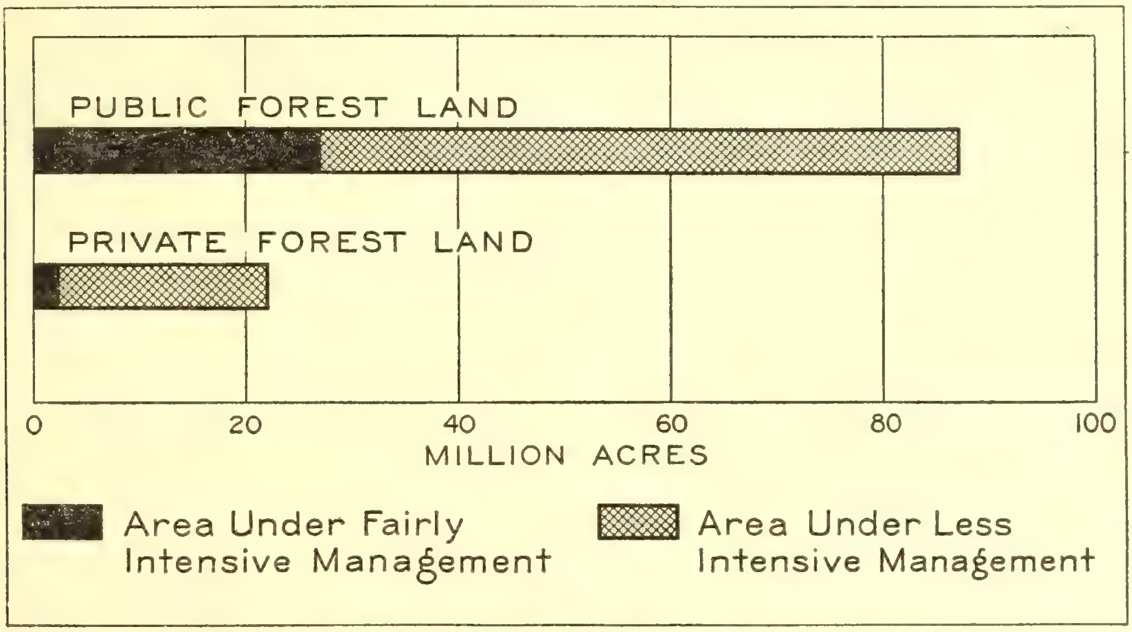

FIGURE 8.—The low acreage in private ownership under some form of forest management throws public accomplishment into high relief. The public total is, however, relatively small in the light of the effort needed to meet national timber requirements.

For the country as a whole, however, where the condition is dominated by private land, the drain for timber of all sizes now exceeds growth by nearly 2 to 1, while for saw timber it is 5 to 1. But 70 percent of the drain is still in saw timber sizes.

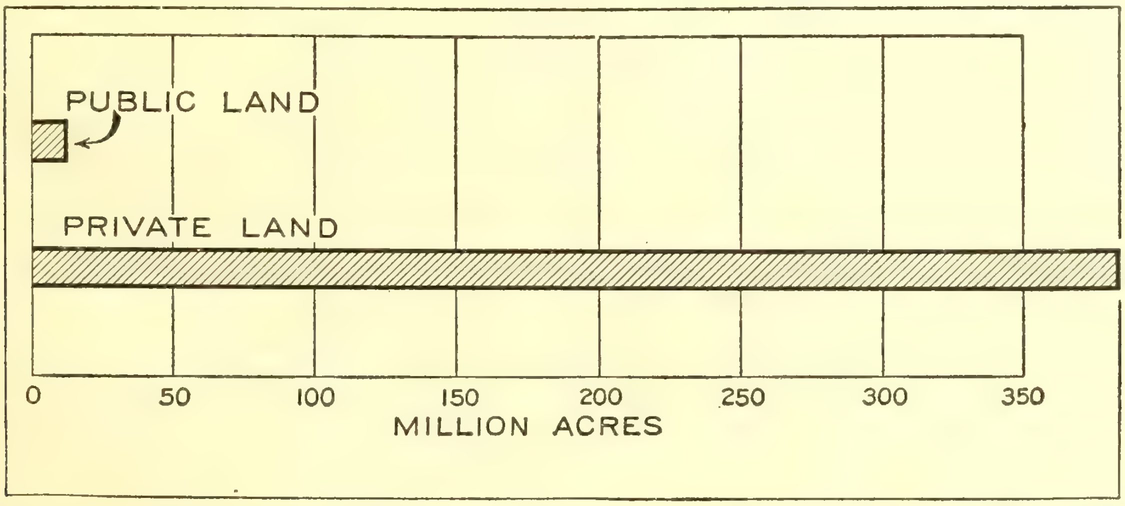

FIGURE 9.—Area with no forest management. While some of the large area in private ownership, which contains the best timberland, may remain productive, much of it deteriorates, the forest capital is reduced, and yields are less than management of any sort would produce.

While farm woodlots ordinarily receive far less attention than any other part of the farm, cutting practices have been much less destructive than on industrially owned lands. Isolation has been a factor in much better protection.

The remarkable recuperative power of the forest, rather than any conscious effort by private owners, has been the main factor in the existence of 81 million acres of second-growth saw timber, 105 bearing young stands of cordwood size, and of 90 with fair to satisfactory restocking.

The public employs about five times more trained professional foresters than do private owners.

The relative efforts of public and private agencies are perhaps roughly expressed in the expenditures for 1932 already stated and shown graphically in figure 1.

About two thirds of the public expenditures, which are nearly 90 percent of the total for the year, are devoted to public lands and mainly to the commercial forests which constitute only one fifth of the total area of commercial forests.

Less than half of the private expenditures of 10 percent of the total are used on four fifths of the commercial lands.

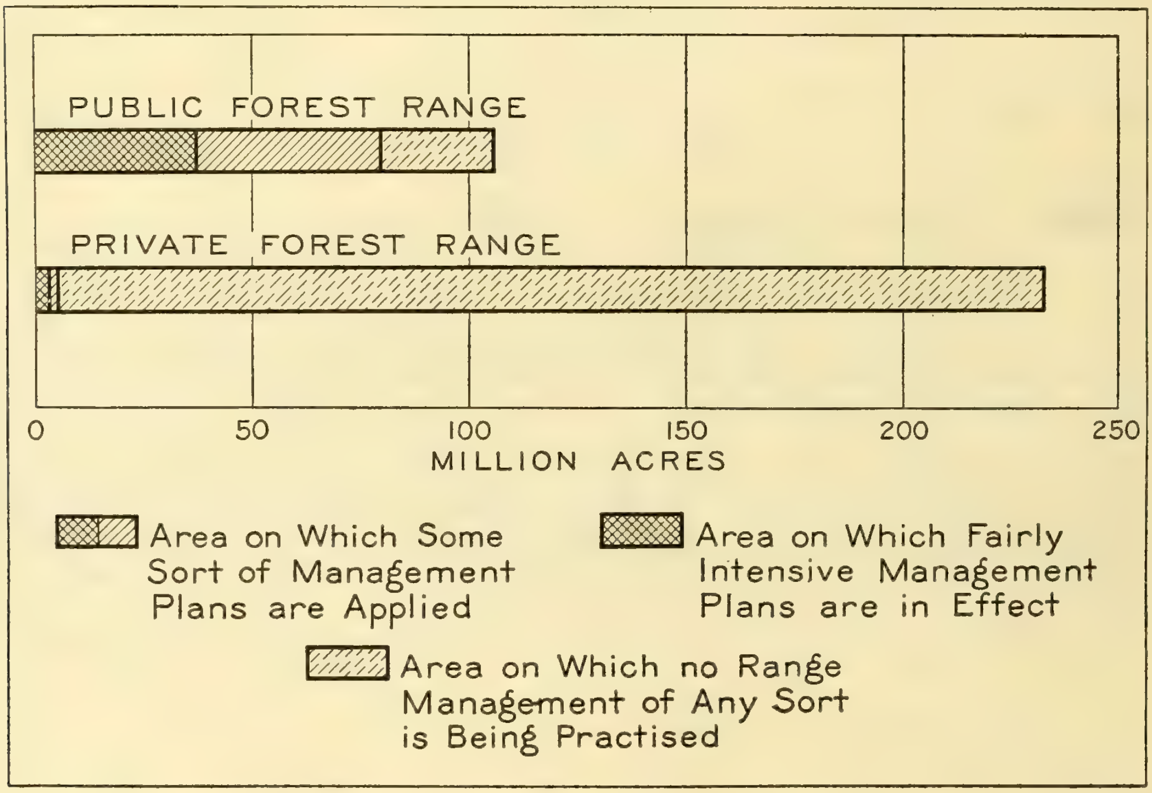

FIGURE 10.—Management of forest ranges. About two-thirds of the area is in private ownership, but public agencies have put a far larger area under management.

The extent to which private has fallen behind public ownership is summarized graphically on a percentage basis in figure 11. The distribution of expenditures is further shown in figure 12.

THE PROBLEM OF THE AGRICULTURAL LAND AVAILABLE FOR FORESTRY

A total of over 50 million acres east of the plains originally forested but not now included in the forest land classification is estimated by the Bureau of Agricultural Economics to have already been abandoned by agriculture and to be available for forestry.

It is made up of abandoned farms that have gone out of production, of idle or fallow land in farms still operated and of former pasture lands.

Abandonment is still in process. The Bureau of Agricultural Economics estimates that if present trends continue, approximately 15 million acres more may be abandoned by 1940, and from 25 to 30 by 1950. Further abandonment may be offset to a greater or less extent by increased needs for agriculture.

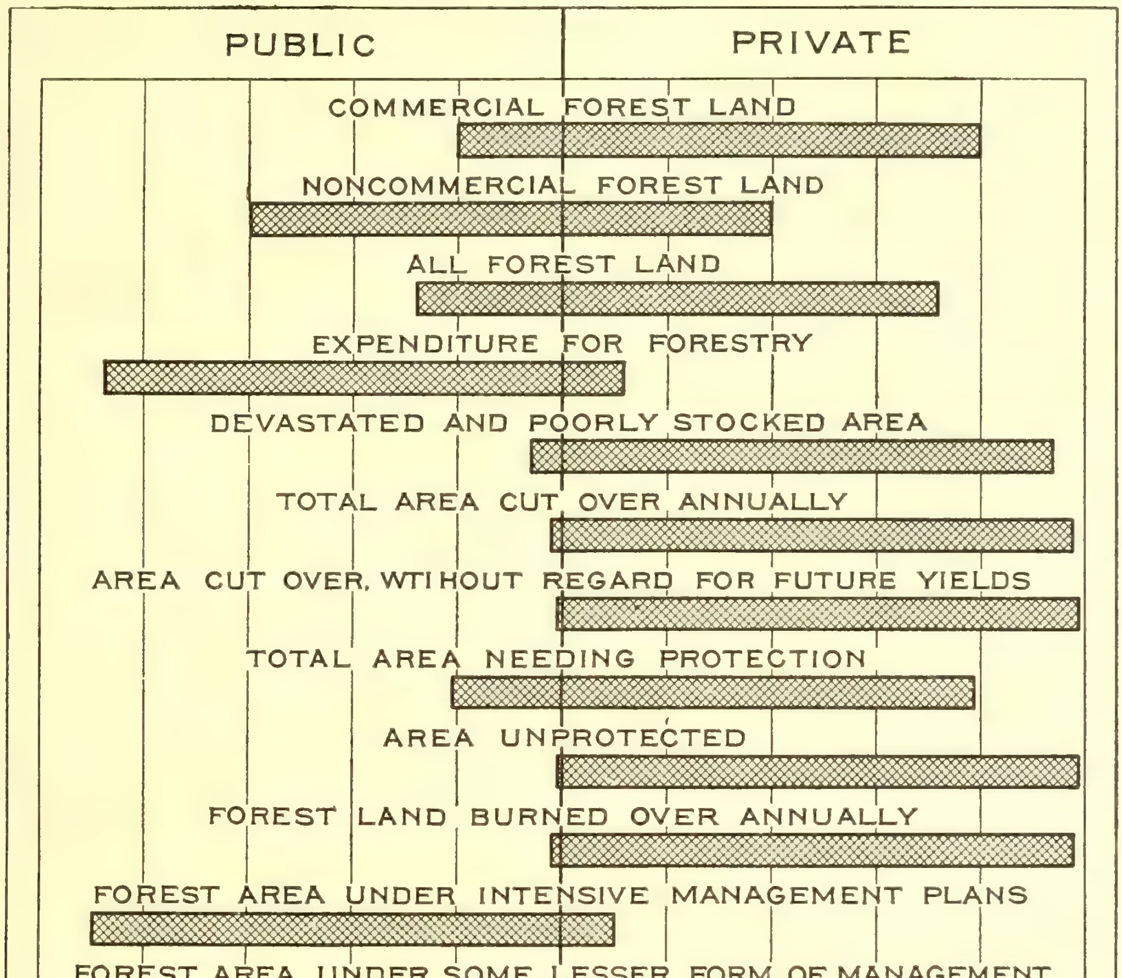

FIGURE 11.—Public and private ownership and forest activities. The public's share predominates in expenditures, in area under management, area planted, and in the number of trained foresters employed. The private owner's share stands out in area devastated, amount of the yearly cut without conscious regard for future stands, need of protection and lack of it, forest area burned, and absence of management plans on both timber and range lands.

The total area of agricultural land now available for forestry is, therefore, more than 50 million acres and may reach from 75 to 80 million acres by the middle of the century.

Abandonment seldom results from a single cause.

The physical character of the land, which may be so lacking in fertility, rough in topography, or stony, that agriculture is unprofitable, is one cause. In many cases the original fertility has been depleted by erosion or repeated cropping.

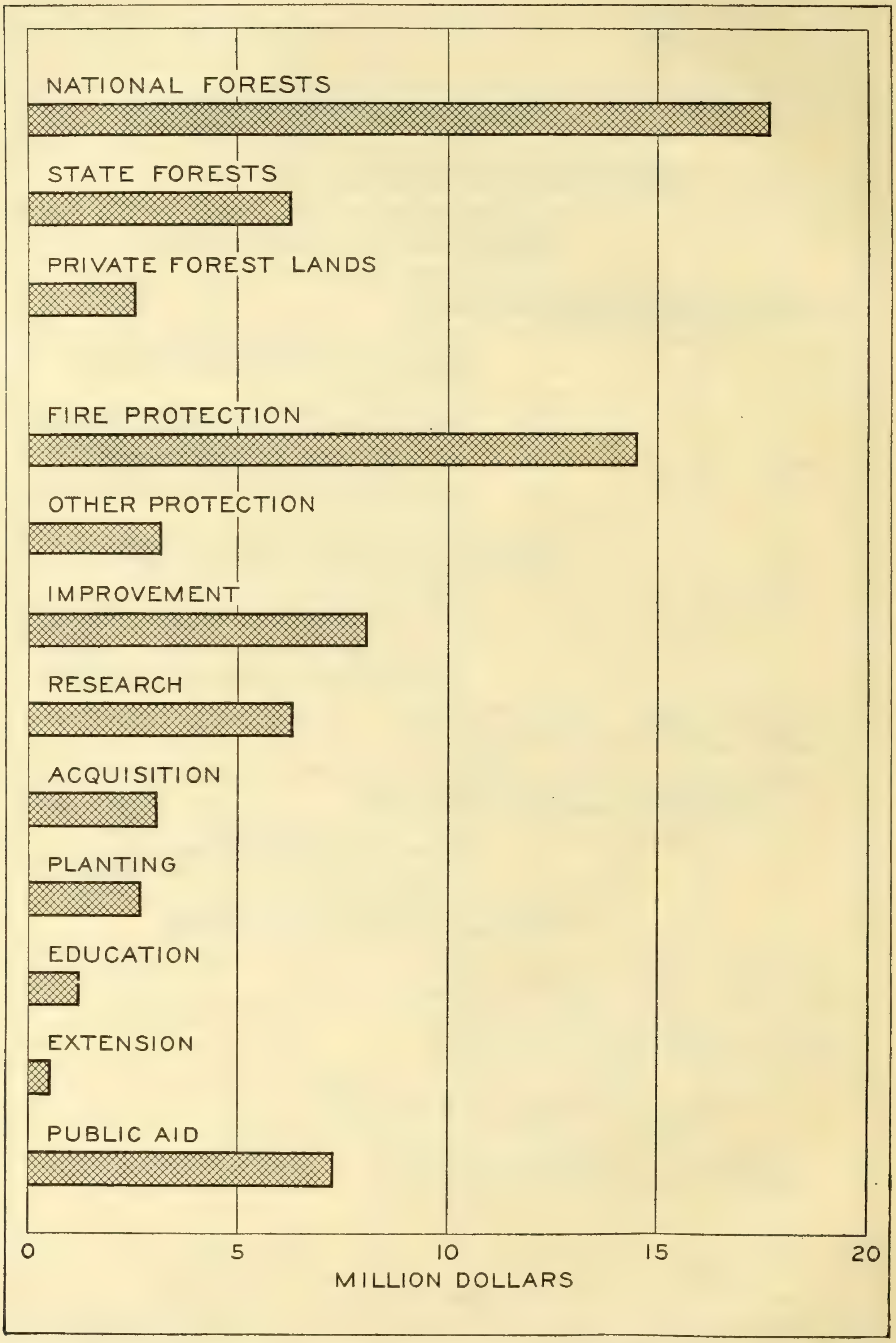

FIGURE 12.—Comparison of activity expenditures in forestry for 1932. The diagram throws additional light on the comparative efforts of different types of forest-land ownership. Even public aid to private owners is approximately three times the expenditures of private ownership on its own land.

Another group of causes are economic. Improved transportation has opened land west of the Alleghenies, first for cereal crops, cattle, etc., and then with refrigeration for dairy products, fruit, and truck crops. Machinery adapted to use on level prairies has been developed. The opportunities in commerce and manufacture have attracted people to the cities. The loss of industries such as lumbering has led to loss of markets and to higher taxes.

These complex causes have accentuated each other and tended to make abandonment cumulative. The extent to which abandonment will lead to tax delinquency and involuntary public ownership cannot be forecast with any certainty.

The economic and social results are of the same order as those described under the private forest land problem and affect the entire economic and social structure of local communities and even of entire States. All of the unfortunate results react upon and aggravate each other, so that the country no less than the town has its slums and forgotten man.

Some of the most critical erosion and streamflow problems in the United States, as will be shown elsewhere, have resulted from the cultivation of land unsuited for agriculture. Such areas probably constitute a large part of the abandoned agricultural land class.

The abandoned agricultural lands are often of higher potential timber producing capacity than those now remaining as forest lands, but even the forest productivity has frequently been seriously reduced by erosion.

The abandonment of submarginal agricultural lands constitutes still another problem of private ownership of major importance.

THE PROBLEM OF UNMANAGED PUBLIC LANDS

THE FEDERAL PUBLIC DOMAIN

Not all of the major forest problems are those of private lands. The Federal Government has an unredeemed responsibility and an unsolved problem in the forested public domain of the Western States.

Although the public domain still includes nearly 175 million acres, it is but a remnant, not much more than one tenth of the original public domain, and naturally the area of lowest value from the private standpoint. Of this remnant about 23 million acres are forest land, including somewhat over 4½ million acres of commercial forest.

It receives at best only inadequate fire protection. It is given no timber management. Unrestricted private use of the range has reduced the forage cover over large areas to less than half its original density and on some areas to practically nothing. The valuable forage plants have suffered most. Under unrestricted private use it constitutes one of the most critical erosion and flood problems in the West.

No valid reason exists for delay in giving national forest status to the larger part of these lands and thus insuring the necessary management. The remainder should be placed under administration with the public domain.

An additional area of more than 2 million acres of revested Oregon and California Railroad and Coos Bay wagon-road grants is forest land. Management goes no farther than fire protection. The timber may be cut without any provision for restocking. Under existing law this land, after the timber is removed, is open to agricultural entry for which it is unsuited; if the timber stand is light, it is open before cutting. Some form of permanent public administrati is needed.

THE NEW PUBLIC DOMAIN OF THE STATES AND COUNTIES

The new public domain of the States and counties is growi rapidly from tax reverted forest land while the remaining publ domain of the Federal Government is decreasing. The status of t new public domain is so uncertain that even its area is highly co jectural. Most of it is in a twilight zone between State, county, a private ownership.

In 29 States the title reverts to the counties or towns and in to the State. The 25 million acre total for the Lake, Southern, a Northwestern States already referred to is only a part of what already tax delinquent. The possibility that half of the forest la area in the Lake States will be in public ownership in 10 years some indication of what is likely to happen to a greater or less exte elsewhere. The productivity of much of the tax-delinquent fore land has been wrecked by forest devastation so that private owne have no further interest in it.

In most States no effort has been made to define the status of t land by law or to attempt any administration beyond partial a inadequate fire protection. Only seven States have laws which ev look toward classification and permanent administration. The in cations are that some of these States will be overwhelmed with t problem. It is merely another instance where the development political machinery has lagged seriously behind econonic events.

This public-ownership problem has grown directly out of one pha of that of private ownership.

Sooner or later more or less of the abandoned submarginal ag cultural land already discussed will probably also become tax deli quent. When and as it does, still another problem of private-la ownership will become an even more serious public problem. N York alone has made definite provision for solving it by setting u 20-year program of acquisition and reforestation.

An additional area of State forest land of more or less uncerta status, and only in part under any form of management or prot tion, is the remnant of Federal land grants to the States. It tot several million acres.

Minnesota, Washington, and Montana alone have legally defin its status and made some provision for blocking it into State fore and placing it under management. In Idaho, Arizona, and N Mexico similar policies depend soley upon the decision of the Sta public-land administrative agency.

THE PROBLEM OF BALANCING THE NATIONAL TIMBER BUDG

DRAIN AND REQUIREMENTS

The total drain from the forests of the United States is now abo 16⅓ billion cubic feet.

Nearly 90 percent is cut and the remainder is the loss from f and other causes. Of great significance is the fact that about percent of the total drain, or the equivalent of about 59½ billi board feet, is from the large or saw-timber sizes. The largest sin item in the cut, about one half of the total, is for lumber, while fuel wood is nearly 30 percent.

The requirements of the future will be influenced by a large number of factors, the resultant of which cannot be predicted with certainty. It seems wise, however, to base plans for the future upon the best judgment that can be formed of probable normal requirements making reasonable allowance for losses that occurred during the predepression period and for factors that might affect future rates of consumption.

On this basis the conclusion has been reached that our forests should be put in the condition to meet an annual drain of at least 16½ billion cubic feet for all purposes, including unpreventable losses from fire, insects, and diseases. A conspicuous part of these normal requirements so determined is 55 billion board feet of saw timber. This, for lumber, the most important product, would provide an annual cut of 32 billion board feet.

CURRENT AND NECESSARY GROWTH

Against current drain and probable normal requirements must, among other things, be balanced present and possible growth.

From the best data now possible to obtain, present growth is estimated to be about 9 billion cubic feet annually in timber of all sizes. The ratio of normal drain to growth is therefore nearly 2 to 1.

Growth of the all-important saw timber is somewhat less than 12 billion board feet. The ration of requirements to growth of this material is therefore about 5 to 1. The ratios for both classes of timber are shown in figure 13.

Of great importance also is the fact that drain and requirements for saw timber exceed current growth in varying ratios in every important forest region of the country, and with possibly one exception, for timber of all sizes.

The problem of balancing the timber budget is therefore in part, approximately to double the growth for timber of all sizes for the country as a whole, and in part also to increase that of saw-timber size by five times.

That this is within the realm of possibilities is shown by the fact that present growth averages per acre only 21 cubic feet, whereas in such a region as the South it ought to be possible to obtain 50 cubic feet by extensive forest management and 75 cubic feet by intensive forest management, both over large areas. Similarly in the Pacific coast region it should be possible to obtain growths of 45 cubic feet by extensive and 75 cubic feet by intensive forestry.

THE REMAINING TIMBER AND ITS AVAILABILITY

The virgin timber supply, which has always obscured the need for timber growing, is still a factor to be taken into account in balancing our national timber budget.

Four fifths of the all-important saw timber, of which we still have 1,668 billion board feet, is old growth. Four fifths of the saw timber and over nine tenths of the old growth is, however, in the West, while the large consuming markets are in the East and Middle West.

But availability is far more important than amount, and almost half the total is economically unavailable because of inaccessibility and other factors, on the basis of 1925–29 operating conditions and lumber prices. What the ultimately available amount will be depends upon such factors as demand, prices, changes in logging methods, and the competition of other materials.

Of timber of all sizes we still have left 487 billion cubic feet, 56 percent of which is in the West.

The problem of balancing our timber budget is complicated by the deficiency of the growing stock in all parts of the East, and particularly in the South, which has by far the largest potential growing capacity of any region of the country.

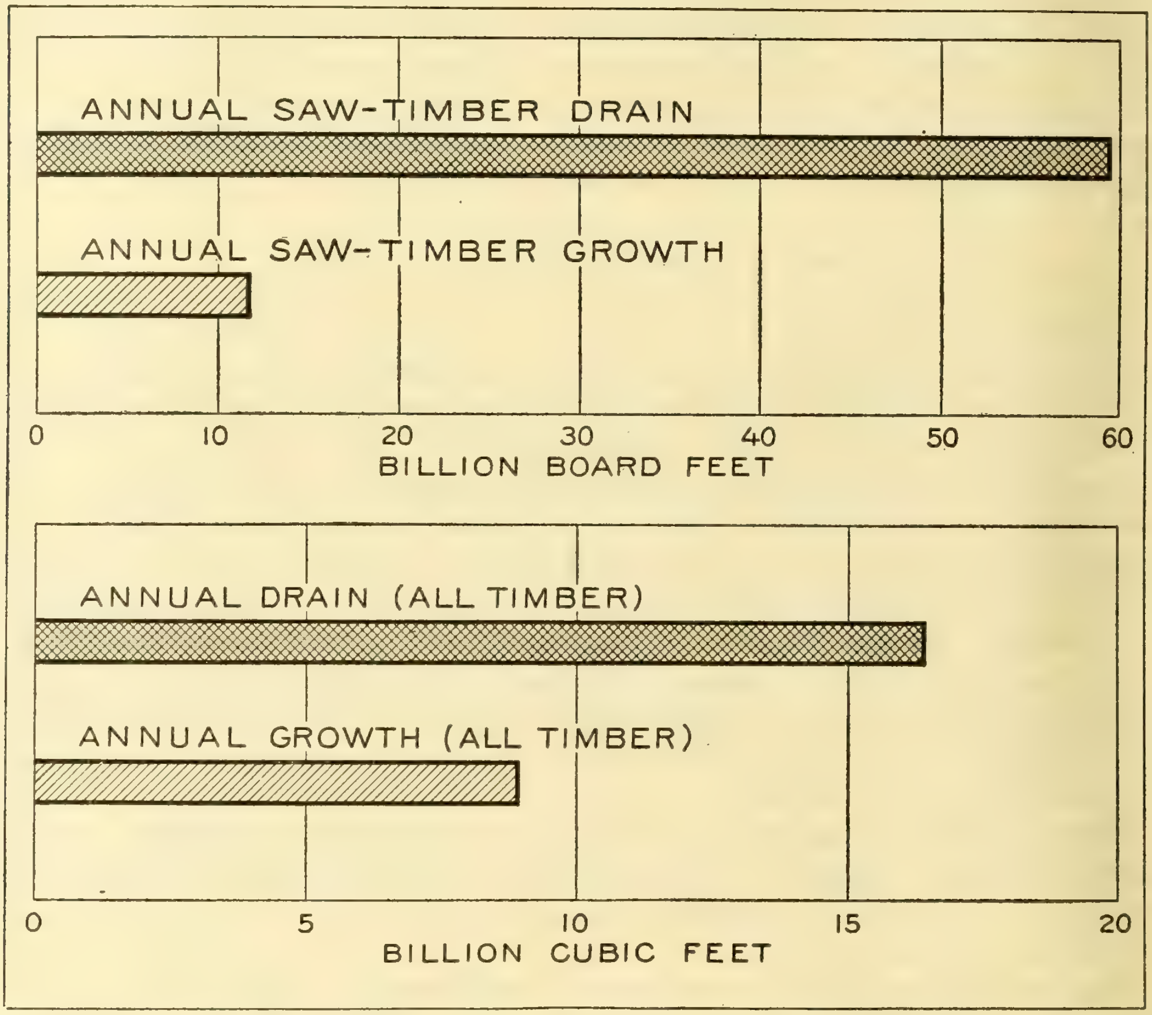

FIGURE 13.—The growing of the large saw-timber sizes is the critical factor in balancing the national timber budget. The saw-timber drain on our forests is 70 percent of the total drain and is about five times saw-timber growth.

MAKING UP THE DEFICIENCY IN GROWING STOCK

A regulated growing stock for the country as a whole, with saw timber equal to present volume, would make possible a sustained yield cut of only 46½ billion board feet, or with saw-timber volume equal to that having positive utilization value, only 26½. These amounts must be compared with a drain of 59½, and estimated normal requirements of 55.

The magnitude of the problem of increasing the forest capital in the entire East by the necessary two and one half times will be apparent when it is made clear that this must be done in the face of a 1925–29 drain which exceeds current growth by nearly 29 billion board feet for the all-important saw-timber sizes. This is shown graphically in figure 14.

PRIVATE OWNERSHIP THE LIMITING FACTOR

Private ownership is the limiting factor because it holds four fifths of the commercial forest land, with at least 90 percent and possibly more of the potential growing capacity (fig. 15). Under the present distribution of ownership nearly the entire deficiency of growing stock must be made up on private land, which it has as yet been the practically universal tendency of private practice to reduce rather than to build up.

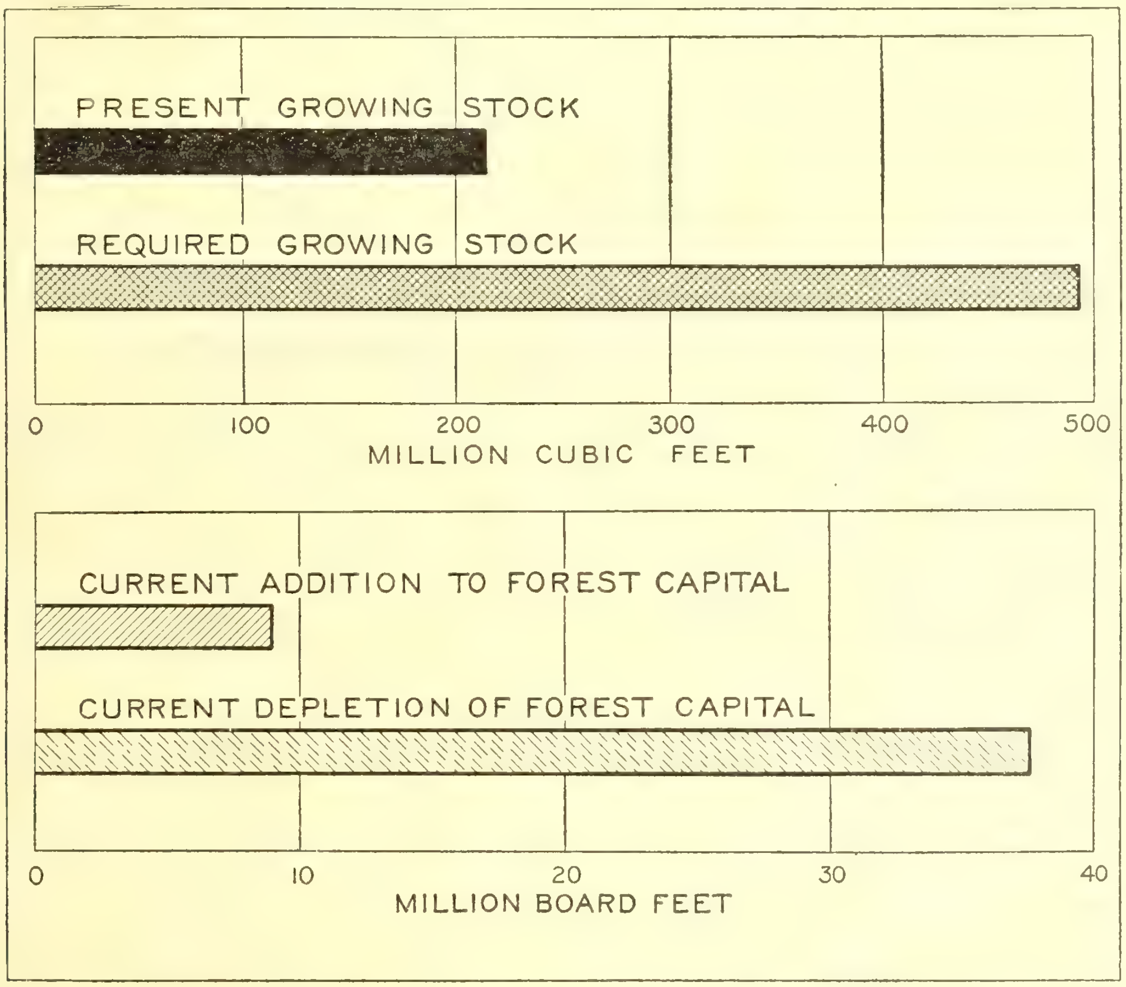

FIGURE 14.—Growing stock or forest capital in the East. The increase of the forest capital for the entire East by two and one half times is a prerequisite in raising growth to the level needed to meet national requirements. But the saw-timber portion of the growing stock is being reduced by some 29 billion board feet annually.

THE PROBLEM OF WATERSHED PROTECTION

The service which the forest may render in watershed protection is probably as great in value as in the production of wood, and may be greater.

The possibility of protective service ranges from great river systems like the Mississippi to the "dry" washes of a few acres in the semiarid West. It is not confined to the headwaters but may be most acute on the very bluffs of great streams like the Mississippi.

THE IMPORTANT PHASES OF THE PROBLEM

The main urban centers of the east coast from Boston to Baltimore consume more than 2 billion gallons of water daily. Large cities are bringing their water supplies from distances of 60, 92, 200, 250, 450 miles at costs, actual or proposed, ranging upward to $350,000,000 for a single project.

Extreme droughts such as that of 1930–31 show the acuteness of the domestic water supply problem even in the humid East. In southern California if not elsewhere the availability of water definitely limits the size of the population. All cities must have abundant, continuous supplies of good water.

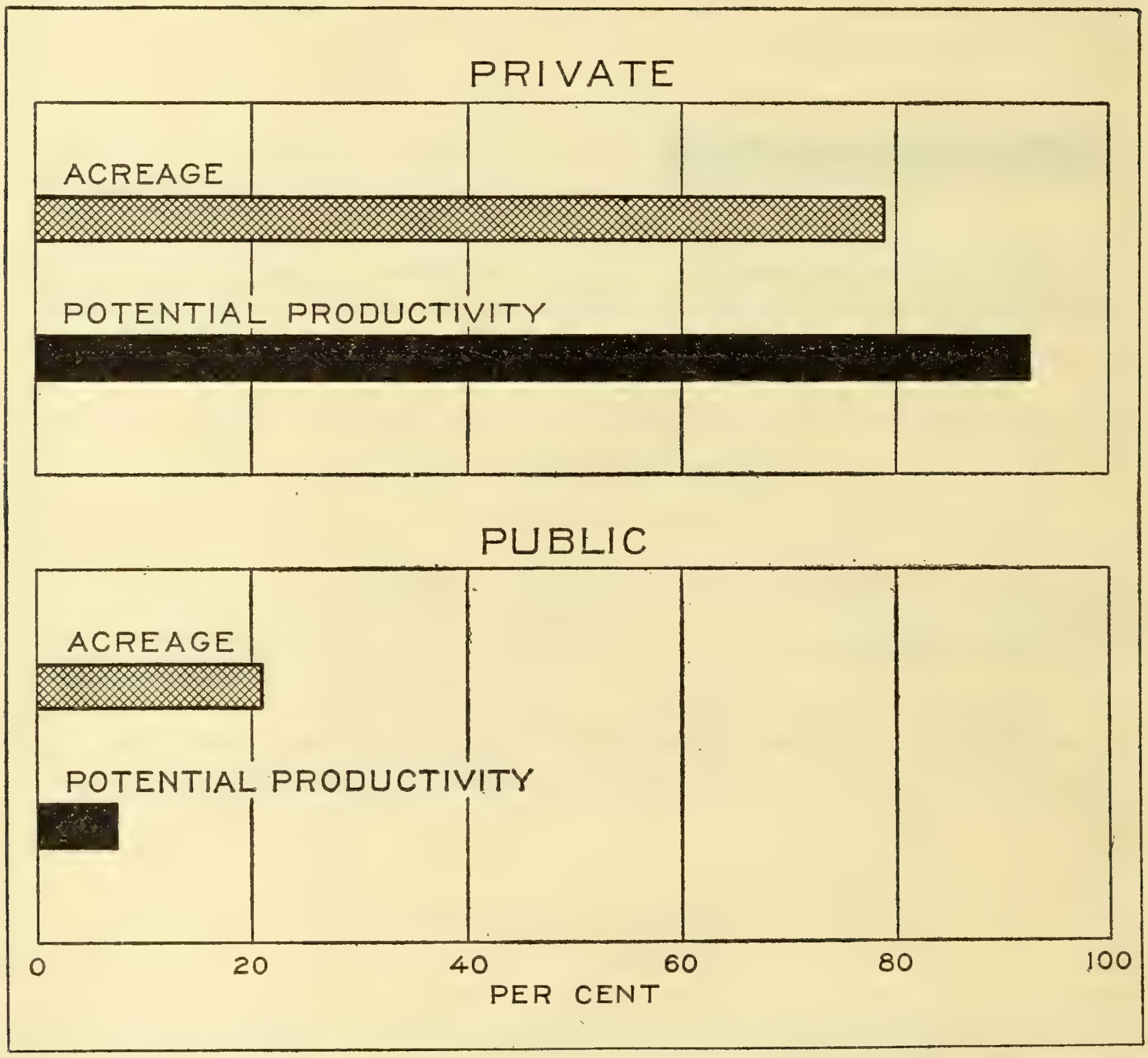

FIGURE 15.—Private ownership dominates the possibility of timber production in the United States, with four fifths of the commercial forest land and nine tenths or more of the potential timber growing capacity.

Nineteen Western States now have reservoir and distributing systems for irrigation, valued at more than $1,000,000,000, to supply about 19½ million acres of irrigated land which with its buildings and machinery is valued at over $4,000,000,000. Far-western agriculture is largely that of irrigated lands. The amount and the time at which water is available are limiting factors, since there is much more land than water.

Water is one of the great sources of power in the United States and, unlike coal and oil, it is not exhaustible. In 1931, 26 States had developed more than 100,000 horsepower each from their streams, ranging downward from 2,321,000 in California to 135,000 in Virginia.

Regular stream flow, freedom from silt that will fill reservoirs are important factors in all water power development and use.

The importance of watershed protection is indicated by the fact that the Federal Government has been willing during the past 50 years to expend for the improvement of our rivers and harbors in excess of $2,000,000,000. Again regularity of flow and freedom from silt are vital factors in the availability, use, and cost of maintenance.

Floods occur in every part of the United States and damages range downward from the great Mississippi disaster of 1927, estimated at 246 lives and $300,000,000, to those caused by local floods so small as to escape notice. Every year has its quota.

Expenditures for major engineering works for flood control have run into the hundreds of millions of dollars, but the problem is far from solution. There is ample reason to believe that fully satisfactory control must utilize all means at our disposal, including the forest.

Excessive erosion, either spectacular or so inconspicuous as to go unnoticed, is common to nearly all parts of the United States. It occurs on agricultural, range, and forest land. It loads streams with silt, clogs irrigation works, navigable channels and harbors, fills reservoirs, increases the height of floods, and adds enormously to their destructive power.

Because it first removes the fertile top layers of soil it is a primary cause of land abandonment. It is undoubtedly the most destructive agency affecting our greatest basic resource, the soil.

THE RELATION OF THE FOREST TO WATERSHED PROTECTION

General observational studies in the United States have substantiated both the popular conception and European experience that the destruction of the forest cover leads to erosion and that the presence of such cover is the most effective means for erosion control.

Furthermore, they have shown that the forest will rebuild the soil.

Intensive research makes the relationship between forest cover and erosion still more conclusive. Results in different parts of the country on different soils with varying precipitation, etc., show that the ratio of erosion between barren forest land and that with forest cover may vary all the way from 15, 1,000, and 3,920 to 1.

It has been estimated that 1,000 years may be necessary to build up an inch of soil, an amount which often is removed by erosion in 1 year.

Observational studies have shown that destruction or deterioration of the forests is one of the major contributing causes of excessively rapid run-off and destructive floods, and that the presence of the forest retards the rate of run-off, puts the water into the soil and underground channels, reduces the height of floods, increases summer flow, and delivers water free from sediment.

Intensive research shows that the ratio of run-off between denuded and forest-covered soils varies from 3, 110, and 187 to 1, with intermediate ratios for partially destroyed forest.

Among the chief causes of forest destruction in relation to water protection are fire, logging, overgrazing, and smelter fumes. The most critical watershed conditions in the United States have, however, resulted from clearing for agriculture.

The best classification possible with the data available indicates (fig. 16) that 308 million acres or half of the forest area of the United

States exerts a major influence on watershed protection and that an additional one fifth exerts a moderate influence.

THE MOST CRITICAL CONDITIONS

The most critical watershed conditions resulting from the clearing of land for agriculture are the Mississippi bluff and silt-loam uplands, the piedmont and upper coastal plain in the Atlantic and Gulf drainages, and the Central State farm lands of the Mississippi Basin.

The bluff and silt-loam upland area, approximating 20 million acres, extends from New Orleans to St. Paul. Its wind-blown silt-loam soils contribute more to the Mississippi silt problem than any other area of equal size. A high percentage of the area, in some cases 40 percent of entire counties, is being rapidly destroyed for agriculture by erosion. It is an enormous contributor to the serious Yazoo flood problem, where experimental tests have shown a run-off ratio between cultivated fields and forest of 127 to 1.

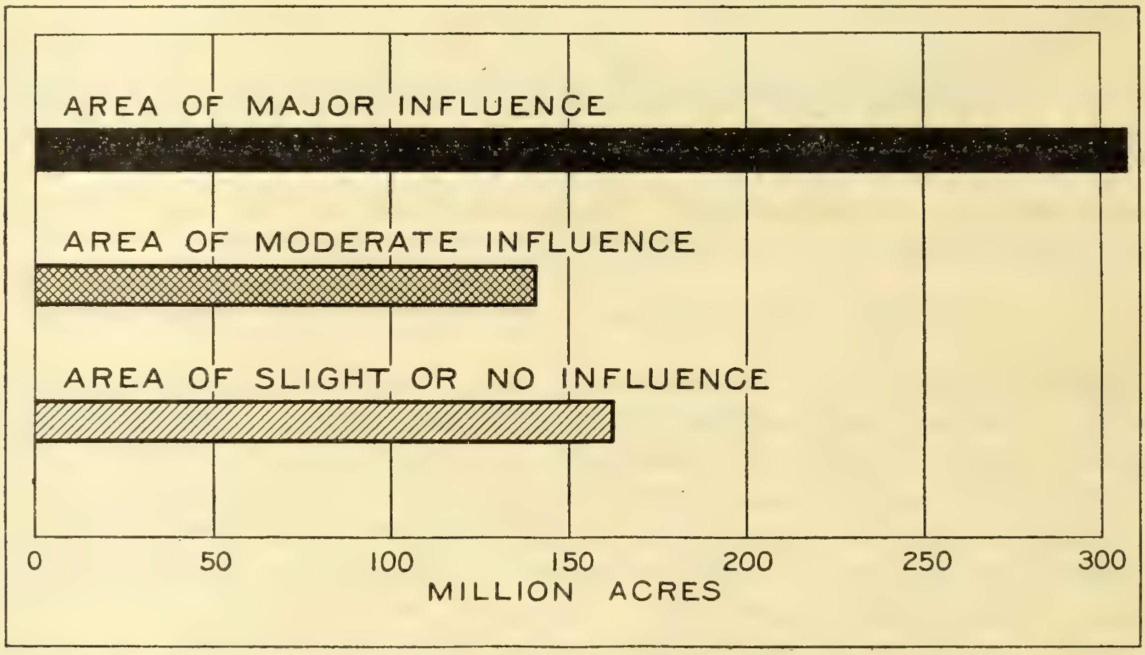

FIGURE 16.—One half of the total area of forest land of 615 million acres is classified as having a major watershed influence and nearly three fourths as having a major or moderate influence. This indicates only in part, however, the value of the forest for watershed protection.

Erosion and floods are hardly less serious on the much larger piedmont and upper coastal plain extending from the Potomac into Mississippi. Largely as a result of erosion, at least 8½ million acres have been abandoned for agriculture in the past 20 years and trends indicate a total of 12 million by 1950.

The Central States farm land area, including parts of 10 States from West Virginia and Ohio to eastern Kansas and Nebraska, makes another large contribution to the Mississippi River flood and silt problem. The abandonment of 15 million acres of farm lands in the area of most critical erosion conditions seems to be only the beginning.

The watersheds of the northeastern drainages derive their chief watershed importance as the source of the municipal supplies of the great Eastern cities from Boston to Baltimore. The forests most in need of improvement are in the southern half of the area.

The Appalachian Mountain ranges feed the Mississippi and its tributaries, and the Atlantic coast and Gulf rivers from the Delaware to the mouth of the Mississippi. Heavy and frequently torrential precipitation, easily eroded soils, the clearing of steep slopes for agriculture, and deteriorated forests accentuate the watershed problem.

The Ouachita-Ozark Mountain area of Arkansas, Oklahoma, and Missouri make up only 5 percent of the Mississippi River drainage, but have contributed from 25 to 50 percent of the peak flow of the lower-river floods. No other area of equal size is as great a factor in flood height. Hillside agriculture, cutting without provision for the future of the forest, fires that burn one seventh of the area annually have markedly reduced the possible watershed protection.

The Breaks of the Arkansas and Red Rivers and the Badlands of the Missouri contribute a volume of sediment to the Mississippi far in excess of the proper proportion of a total area of only 20 million acres. The cutting of the sparse tree growth and excessive grazing are partly responsible.

Only an exceptionally luxuriant vegetative cover saves the Pacific coast dense forest region with its heavy precipitation from being an extremely critical watershed problem.

The ponderosa-lodgepole pine belt forests are the source of two thirds of the irrigation water of the West, of one third of the 14 million installed horsepower capacity of the country, and of municipal supplies for 6 million people. Destructive cutting, fire, and unregulated grazing have reduced the effectiveness of the cover over large areas.

Eighty million acres of semiarid woodland and brush lands constitute the most critical western erosion and flood problem on forest lands. Depletion of the normally sparse vegetative cover chiefly by destructive grazing and fire have seriously impaired its protective values.

THE RELATION OF OWNERSHIP AND MANAGEMENT TO CRITICAL PROBLEMS

Private land ownership is the key to the watershed problem on eastern agricultural lands, to practically all of the forest-land problem of the East, and also to the ponderosa-lodgepole pine problem of the West.

The unmanaged public domain, which includes over 23 percent of the semiarid woodland and brush lands, constitutes the most critical erosion and flood problem on western forest lands.

THE PROBLEM OF FOREST RECREATION

Recreation in this report means anything done directly for the pleasure or enrichment which it brings to life, in contrast to things done primarily to obtain the necessities.

People who visit the forest for recreation have a great variety of purposes. It may be the desire for play, the preservation of health, the pursuit of beauty, communion with nature, favorable environment for contemplation, scientific knowledge, adventure, or to escape from civilization. While few go to the forest for all of these purposes, each one influences at the very least tens of thousands of people.

The best available figures on current annual volume indicate about 250 million man-days spent in recreational use of the forest and an expenditure by forest recreationalists of not less than $1,750,000,000.

Recreational use jumped from about 300,000 to 3 million visitors in national parks and from 3 million to 32 million visitors in national forests between 1917 and 1931.

There is good reason to anticipate a great increase in the future. The factors which will cause this growth include an increasing population, shorter working hours, a probable rising standard of living, the increasing ease of transportation, and the increasing necessity, as society becomes more and more mechanized, for some possibility of escape to the primitive.

The use of the forest for recreation seems therefore to be in its infancy. We probably as yet have only a limited conception of the ultimate possibilities and needs for this social service in a highly industrialized nation.

Practically all forest land which has not been severely damaged by fire and logging has some recreational value. Sustained yield timber growing will preserve much of the attraction for recreationalists. Since even the best silvicultural practice does not conserve all recreational values, it is necessary to set aside a limited area exclusively for recreation.

One phase of the problem is to anticipate the full range and volume of needs and possibilities.

Another is to decide what kind of forest areas are needed, whether superlative, primeval, wilderness, roadside, camp site, residence, outing, or others; how many of each there should be, how large, and how they should be distributed.

Still another phase is that of ownership. Forest devastation or deterioration for immediate income, which has characterized private ownership, does not conserve recreational values. A further question is whether permanent preservation can be insured except in public ownership. It may be questionable whether lands in private ownership will be open to permanent use by the general public.

THE PROBLEM OF FOREST WILD LIFE

THE DEPENDENCE OF WILD LIFE ON THE FOREST

The forests of the United States provide all or part of the habitat for a large percentage of our remaining wild life, important for food, fur, and hunting, or for esthetic purposes.

The streams and lakes dependent upon forest land also constitute the most favorable habitat of many valuable game fishes and the temporary habitat during early life of some of the important commercial anadromous fishes such as salmon and shad.

ECONOMIC AND SOCIAL VALUES

The Senate Committee on Conservation of Wild Life Resources places the total hunters and fishermen in the United States in 1929 at 13 millions, and estimates that this is a 400 percent increase in a decade. The number promises to increase along with the increase of outdoor recreation which will come with increased leisure and facilities for travel.

The direct values of wild life include the sale of hunting licenses, the value of meat and fur, the sale of hunting and fishing equipment, expenditures of sportsmen, and the value, chiefly of birds, as destroyers of insects. The Biological Survey estimates the total positive national value of wild life at over $1,000,000,000 annually.

The commercial fisheries of the Mississippi and its tributaries in 1930 produced values of $4,385,000. For the year ending June 30, 1932, approximately 4,850,000 State licenses carried the angling privilege. The value of fishing tackle sold annually was estimated in 1929 by a trade association at $25,000,000.

THE DEPLETION OF WILD LIFE

In general wild life has decreased and is still decreasing on much of the forest land of the country. Some species have been almost exterminated. This is also true of fish. Many waters which were well stocked only a few years ago are now seriously depleted.

The reasons are the far greater number of hunters and fishermen, the lack of adequate control, disease, and the deterioration or destruction by fire or otherwise of forest cover and other essential conditions of habitat. The floods and erosion which commonly follow forest destruction or deterioration are an important cause of the scarcity of fish.

THE POTENTIALITIES OF WILD LIFE UNDER MANAGEMENT

The numbers of game animals on the national forests are estimated to have increased 40 percent between 1926 and 1931 as a result of management. Certain species, such as deer, are unquestionably increasing appreciably over considerable areas in many parts of the country and under favorable conditions, including the regulation of hunting.

In general the wild-life population of the forest is far below what it might be. One of the important problems is to work out forms of management on the principle of sustained yield, which involves proper stocking, the furnishing of food and cover requirements, protection from natural enemies and other injurious factors, and the removal of surplus only.

One of the most important aspects of management for land forms of wild life is that of coordination with timber production and utilization, and the grazing of domestic livestock.

Special aspects of the problem of building up numbers of fish include their introduction into waters in which they are not native, artificial propagation and stocking, protection from overfishing, and the improvement of streams and lakes to provide more favorable conditions. The beneficial effects of forestation on the latter phase can scarcely be overestimated.

One of the complications in wild-life management is that of separate land ownership and wild-life control except where the land is owned by the States. Land ownership may be either private, State, or Federal while wild-life control rests in the State. This phase of the problem involves both wild-life regulation and the possibilities of returns to the private owner. Similar complications exist in the case of fish.

THE NEED FOR PUBLIC HUNTING AND FISHING GROUNDS

Nearly 450 million acres of our forest land is in private ownership, which means that the only assured areas which remain for public hunting are the publicly owned lands.

Although less emphatic than in the case of game, the present tendency is toward the exclusion of the public from the more desirable angling waters within private lands. This creates the same need for public-fishing grounds.

The area of public lands is much the largest in the West because of the existence of the national forests. In the East, the national forests make up only 2 percent of the total area of forest lands. State forests and parks are less than 3 percent.

THE PROBLEM OF FOREST RANGES

Grazing use of 334 million acres, or more than half of the total of 615 million acres of forest land, shows that the forage constitutes one of the important products of the forest.

The large areas which can be so utilized under proper management will increase the returns to the owner, contribute to the economic and social welfare of local communities, and furnish in part the raw resource for the livestock industry.

THE WESTERN PROBLEM

The largest and most critical western forest range problem is that on 42 million acres of privately owned lands.

In an effort to obtain the maximum immediate financial returns, grazing has been so heavy that over large areas the forage resource has been reduced to less than half its original density. This has reduced watershed protection still more and in some instances prevented full timber reproduction and growth. The effects on the livestock industry and economic and social community development and welfare differ only in degree from those of forest devastation and deterioration.

The problem of the forest ranges of the unmanaged Federal public domain is equally critical on a smaller area, approximately 21½ million acres. Unrestricted private use of this range has resulted in forage, watershed, forest, economic, and social conditions similar to those indicated in the preceding paragraph.

On about 4 million acres of State forest ranges grazing privileges have ordinarily been leased without supervision of use. Results differ but little from those on privately owned lands and the Federal public domain.

The problem on the 64 million acres of forest ranges in the national forests and the 12 million on Indian reservations is a fuller correlation with timber production and watershed protection and the improvement of the range resource itself now under way but not yet fully completed.

THE EASTERN PROBLEM

The eastern forest range problem is almost entirely one of private ownership.

That of the southern ranges is largely unrestricted use, often by others than the owner of the land, and the uncontrolled use of fire.

That of the farm woodlands, mainly of the Central States, is a decision between range use, the main benefit of which is the shade that could be obtained from a much smaller area, and timber growing which is impossible with heavy range use.

THE PROBLEM OF KNOWLEDGE

THE FORESTRY MOVEMENT HANDICAPPED BY LACK OF KNOWLEDGE

Lack of knowledge of the inevitable consequences has been one among the many factors responsible for the public policy of allowing excessive areas of forest land to go into private ownership.

It has been partly responsible also for allowing large areas of land to go into agriculture which were submarginal for that purpose and which should have been kept in forest.

Still further, it has been partly responsible for the delay in putting under administration forest land remaining in the Federal public domain and for the delay by the States in recognizing and providing for the still larger area which by reversion to public ownership via the tax delinquency route is becoming a new public domain.

Lack of knowledge has been one of the factors which has led private owners to adopt the cut-out-and-get-out policy. This in turn led to oversized plants, far too short depreciation periods, excessive capital costs, the cutting of unprofitable timber, lack of provision for future crops, and the devastation or deterioration of a large part of the privately owned commercial forest land.

The manufacturers of wood and particularly of lumber have rested content with rule-of-thumb methods based on centuries of use. The inevitable result has been that new or greatly improved old materials fighting for markets have, by the adoption of modern competitive methods such as research, displaced wood and especially lumber in large volume.

In present-day competition no material, regardless of its intrinsic merit, can expect to hold its own without scientific knowledge of its properties and how to modify them to meet increasingly exacting requirements.

Reliance on rule-of-thumb practice in the utilization of forest ranges has led to the serious deterioration of practically the entire range area for forage production and of some areas for timber production.

The combination of forest devastation and deterioration through unwise cutting and uncontrolled fire, excessive grazing of forest ranges, and the clearing and use of submarginal lands for agriculture, singly or in combination, has created critical watershed conditions in nearly every part of the United States. In all of this the lack of knowledge of the inevitable outcome has unquestionably been one factor.

On both public and private lands efforts to grow timber have started without traditional knowledge such as had been slowly built up by large-scale trial and error in agriculture. European forestry was remote and utilized different species under radically different climatic, economic, and social conditions. Lack of knowledge inevitably led to mistakes, which because of the time required to grow timber crops have been very costly.

It has been and still is a decided factor in the long, slow, uphill fight to get on top of our fire problem. It has led to the ineffective expenditures of large sums of money, great loss in timber and area burned, and still greater loss in reduced productivity of land.

It has delayed the natural reforestation of cut-over forests. In planting it has led to costly mistakes and delays.

It has brought to the forest wild-life problem only a belated recognition that protection alone has created serious problems which only sustained yield management fully correlated with other forms of forest use can solve.

It still leaves us uncertain regarding the best methods of controlling our most common forms of insect infestation. It has attempted by quarantines to close the door to further importations only after the introduction of such diseases as the chestnut blight, which is practically wiping out one of our most valuable hardwoods, and such insects as the gypsy moth, which has already necessitated expenditures of millions of dollars and is still on our hands.

Lack of even traditional knowledge has almost certainly been a factor, particularly for the private owner, in discouraging any attempt to practice forestry.

It has slowed down progress, impaired efficiency, and increased costs. In these ways, and perhaps still more by not anticipating the great losses caused by erroneous public and private policy and practices, it has been partly responsible for great public and private losses and is still handicapping progress of the entire forestry movement.

RESEARCH DEVELOPMENT BELATED AND INADEQUATE

In typical American fashion the development of research has ordinarily lagged far behind executive action.

The aggressive expansion of research was 15 years behind pronounced national-forest development. Large-scale fire protection and planting long anticipated research to ascertain the best technique.

Repeated attempts to formulate national, regional, State, and industrial policies preceded efforts to obtain authoritatively the facts on which they should be based.

The lumber and other forest industries lost large markets to competitors before beginning efforts to obtain accurate knowledge of their product. By far the largest investigative effort in the forest industries still concerns itself largely with tests to insure a uniform product.

Whole forest regions are still without forest experiment stations worthy of the name. In many important types practically no research has yet been done. A complete and authoritative survey of the forest resources of the United States has never been made. Examples of what we do not know and have not yet attempted to learn, or attempted only inadequately, could be expanded indefinitely.

The aggressive development of forest research has occurred almost entirely since the war, and most of it is far too recent to have produced any but preliminary results. Even the training of men for the work has been largely a post-war development.

EXTENSION NOT EVEN COMMENSURATE WITH RESEARCH

Advice on the ground to the private owner of forest land on how to grow timber is the most poorly organized and financed public activity in American forestry. It is least effective in reaching the industrial owner, who holds more than half of our commercial forest land. The failure of public agencies is not being made up by any others.

The best organized and best financed extension effort is that dealing with farm wood lots. While expenditures reach about $160,000 and work is under way in 33 States, it reached in 1931, to the point of effecting some improvement, only about 1 owner in 100.

Federal extension for industrial timberland owners is an incidental effort by employees whose main responsibility is national-forest administration or research. That in the better utilization of forest products is confined largely to the Forest Products Laboratory, a research institution.

State extension to industrial owners is fairly well organized in only a few States, and expenditures are very small.

Other efforts at extension include a number of associations, most of which work through the press, and a relatively small group of consulting foresters who are very active and effective in reaching private forest landowners on the ground.

WHY THE SOLUTION OF THE MAJOR FOREST PROBLEMS CONSTITUTES ONE OF OUR MAJOR NATIONAL PROBLEMS

The full national significance of the solution of these interrelated major forest problems can be evaluated only by considering them in the aggregate.

SOLUTION THE ONLY MEANS FOR UTILIZING FOREST AND ABANDONED AGRICULTURAL LAND

The only uses in sight for our forest and abandoned agricultural land are for forestry or for farm crops and pasture.

But the demand of agriculture for land is contracting and not expanding. The abandonment of more than 50 million acres of crop and pasture land during the last 2 decades, and the possibility of the abandonment of 25 to 30 million acres more before 1950, is sufficiently conclusive proof of trends.

Beyond this, repeated attempts made to utilize forest land for agriculture over millions of acres in the Lake States, South, and West have ended in failure. Waves of settlers have been put on the lands by timberland owners and by real-estate promoters. The agricultural colleges and experiment stations have devoted years of research and other effort to develop the possibility of agricultural use. All of these efforts have ended in failure except on the best agricultural land.

SOLUTION THE ONLY OR THE BEST MEANS FOR SUPPLYING WOOD AND OTHER RENEWABLE RESOURCES

Despite a falling off of per-capita requirements following the pioneer period, wood promises to keep a permanently important position among our materials. It has high intrinsic value, is easily worked, is relatively cheap, and can in natural and modified forms be used for innumerable purposes. It has the great advantage of being renewable.

Regardless of other considerations, it is in the public interest that it be kept in competition with other products.

Even though it were available from other countries, the advantage of having it at home and near the point of use is very great. But looking to the future and considering conifers for chief use, the hope of obtaining adequate supplies by imports is small. The world in general, like the United States, is overcutting its coniferous forests. World growth, may not be more than two thirds of the drain, and consumption is increasing or at least holding its own.

Under many conditions the forest probably offers the best and cheapest method available for erosion control and stream-flow regulation. On scores of millions of acres the returns for this purpose alone would probably justify the expenditures required for keeping a forest.

The restoration of the forest may also be the cheapest and best means for rebuilding impoverished soils on millions of acres against possible future need for agriculture.

The forest is already one of the great sources of recreation. By taking advantage of improving transportation facilities it can be made to aid materially in solving the problem of how to use the rapidly increasing leisure of all classes of people.

Forest land is the natural and in many instances the only remaining habitat of many forms of wild life, and the same is true of forest waters for fish. Public hunting and fishing grounds are being more and more closely confined to the public forests. Both economic and social values are involved.

Forest ranges can be made to support many millions of domestic livestock for at least a part of the year.

SOLUTION THE ONLY MEANS FOR THE PERPETUATION AND STABILITY OF FOREST INDUSTRIES AND FOR THE FULL DEVELOPMENT OF RELATED INDUSTRIES

The forest industries depend either on the virgin timber resource or new crops. Their present place in our industrial structure is indicated by a predepression capital value including forests estimated at $10,000,000,000 and gross products prior to 1929 averaging close to $2,000,000,000. Ultimate dependence on new crops has been masked over 3 centuries by virgin timber supplies, but the end of these supplies is now definitely in sight. New timber crops will then become the sole means of support for these industries.

Hardly less dependent for full development are the industries based on water derived from forest lands, on forest ranges, forest wild life, and forest recreation.

Many local industries and innumerable small business enterprises are in turn directly dependent on the forest industries. The forests and forest industries are important adjuncts to agriculture, which could hardly exist in many regions without them.

The benefits of stability and permanence in communities, in government, and in social institutions are too obvious to require comment. These can be assured in full measure in forest regions only if the forest and related industries make their proportional contribution.

SOLUTION AN IMPORTANT SOURCE FOR EMPLOYMENT OF LABOR

The development of labor-saving machinery is making means for the profitable employment of labor a critical national necessity.

In 1929 forest work, including logging and wood manufacture, afforded full-time employment or its equivalent to 1,500,000 people. Fully productive forests, at the rate of 1 employee to 250 acres, a conservative estimate in the light of both European and American experience, could employ 2 million people. This does not include the merchandising of forest products and services to forest-products industries. Neither does it include industries dependent upon forest water, forest ranges, forest wild life and recreation, and minor products and services. For all of these a large additional number could be added.

On the public forests alone there is undoubtedly the opportunity for the emergency employment of a very large number of men. Private forests could probably accommodate several times as many.

In fully managed forests, which we cannot have for many years, the opportunity for depression employment would be lessened. The manufacturers of forest products suffer during depressions along with other industries, but the possibility of woods employment might serve to absorb any surplus and prevent the aggravation of unemployment.

SOLUTION OFFERS ONE IMPORTANT AID IN PUBLIC FINANCE

Productive forests widen the tax base. This includes privately owned forests, sawmill, pulp and paper, and other manufacturing plants, the property of industries using other forest products, the property of service industries, and the homes and other property of people engaged in all these industries. The pulp and paper plants in Wisconsin are valued at around $100,000,000 and could be supplied in perpetuity by 2 million acres of well-managed forests.

An enlarged tax base reduces the per dollar of tax base cost of public functions such as local governments, schools, highways, etc. It makes it possible to raise the standards of these functions. It lessens the need for State aid. Almost every county in the cut-over region of Michigan now receives, for example, more money than it pays in taxes.

Even public forests pay a direct financial revenue to local government, which supplements a wider tax base for other property. The national forests return to State and local governments 25 percent of gross receipts. The States pay varying amounts usually on a per acre per annum basis.

The Federal Government itself obtains revenue from the forest and related industries through the income tax.

SOLUTION ONE IMPORTANT MEANS FOR MAINTAINING A BALANCED RURAL ECONOMIC AND SOCIAL STRUCTURE

The solution of the major forest problems offers a means for the utilization of the land for forests which cannot be used for any other purpose, including agriculture. Such utilization should therefore serve as the basis for stable permanent local industries dependent upon the products of both forest and agricultural land.

It should serve as a sound basis for a balanced economic and social structure, which would help to retain in the country a reasonable proportion of the population and help to offset the long-continued movement from the country to the cities. Such a combined forest and agricultural economy should be as nearly depression-proof as any now known.

SOLUTION ONE MEANS TO NATIONAL WELL-BEING AND TO INTERNATIONAL COMPETITION

The economic and social development which is most highly advantageous for many local regions should prove equally so for the country as a whole.

Abundance of raw resources, including land and timber, has been one of the chief factors in the phenomenal growth of the United States. Their continued availability should be of equal or even more value in the future.

Many tendencies indicate for the future an increasingly severe competition between nations in manufactured products. A great advantage should lie with the nations having excess supplies of valuable raw products, like wood which other nations need and cannot grow. The distinct probability that there will be such a need for coniferous woods particularly has already been pointed out.

What is true of national needs and of international competition in peace is much more vitally true in time of war.

SOLUTION NOT ONLY JUSTIFIED BUT IS ONE OF MAJOR NATIONAL PROBLEMS

The 670 million acres of forest and abandoned agricultural land now available for forestry is more than one third of the total land area of the United States. As shown in figure 17, it exceeds by 120 million acres the entire area east of the Mississippi. It is more than half again as large as the area now devoted to farm crops (fig. 18). It exceeds the combined areas of France, Germany, Norway, Sweden, Spain, and Italy (fig. 19).

When to possible benefits of utilizing this vast area of land are added those of maintaining great forest and other industries in prepetuity, of employment for a large number of laborers, of a balanced rural and social economy, of the advantages of national well-being, and of a favorable position for international competition, the forest problem justifies a rating well in the forefront of our great national problems.

The effort which should be made on the forest problem should be rated along with those past, present, or proposed on the Panama Canal, which to date has cost more than $500,000,000; the Hoover Dam, for which $165,000,000 has been authorized; the river and harbor improvements, for which nearly $2,000,000,000 has been expended by the Federal Government alone; the proposed St. Lawrence waterway, the cost of which is estimated at $252,000,000; and even the public highway system, the annual expenditures for which rose from $1,000,000,000 in 1921 to $2,000,000,000 in 1930.

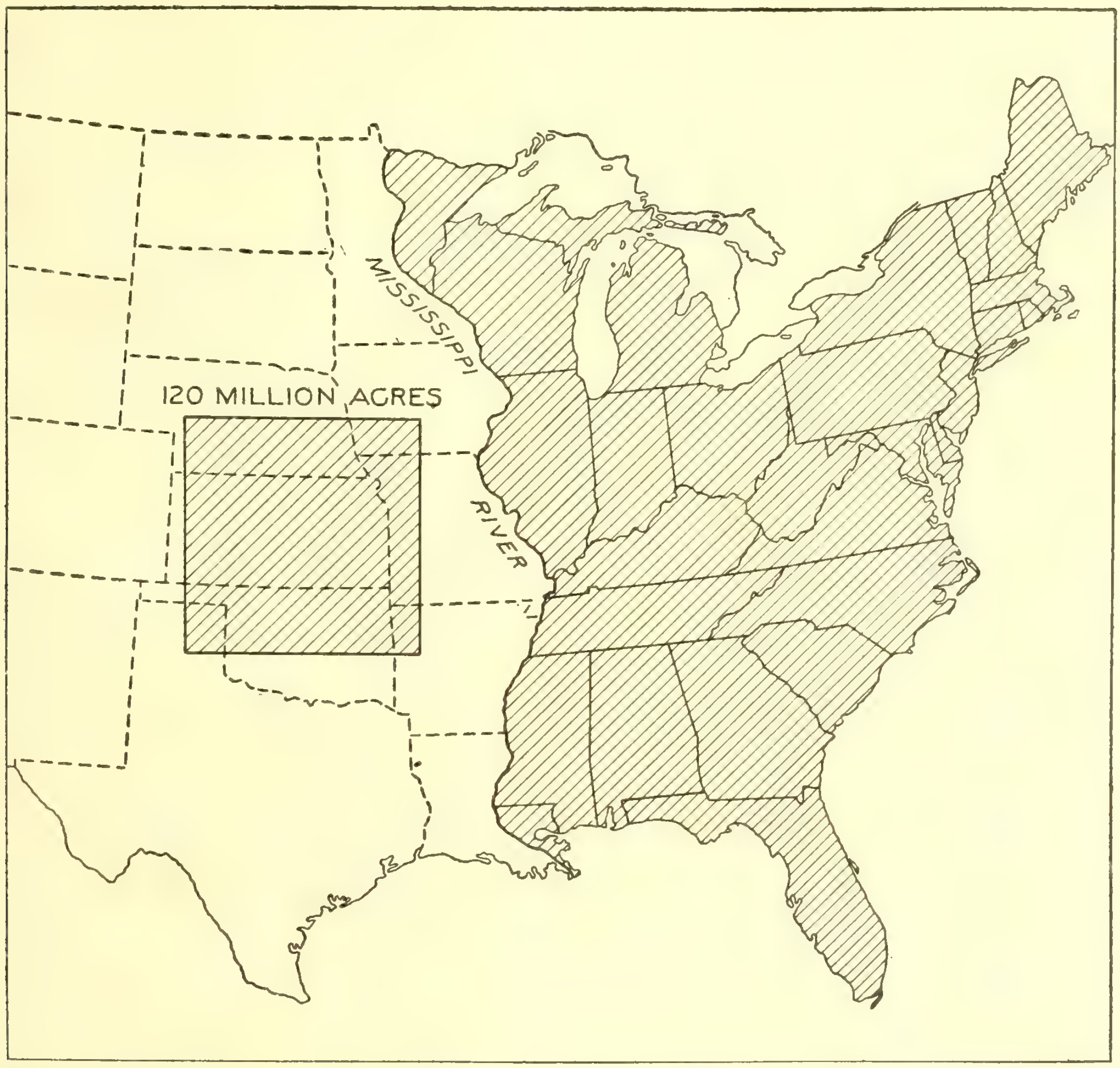

FIGURE 17.—Our forest land area would blanket the whole United States east of the Mississippi, with a substantial block of 120 million acres left over. This gives an idea of what the use of this area would mean in our national land economy.

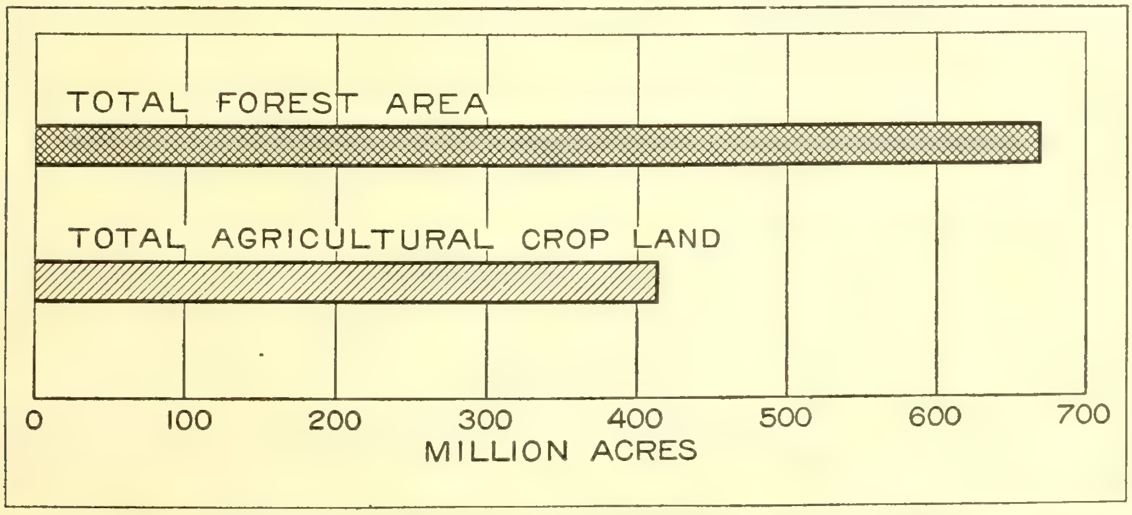

FIGURE 18.—Area involved in the forestry enterprise—half again as large as that devoted to agricultural crops.

THE MAJOR OBJECTIVES

TO GET FOREST LAND INTO PRODUCTIVE USE

From the preceding discussion it is clear that one of the major objectives in the solution of our major forest problems should be to bring, if possible, all our forest land into productive use.

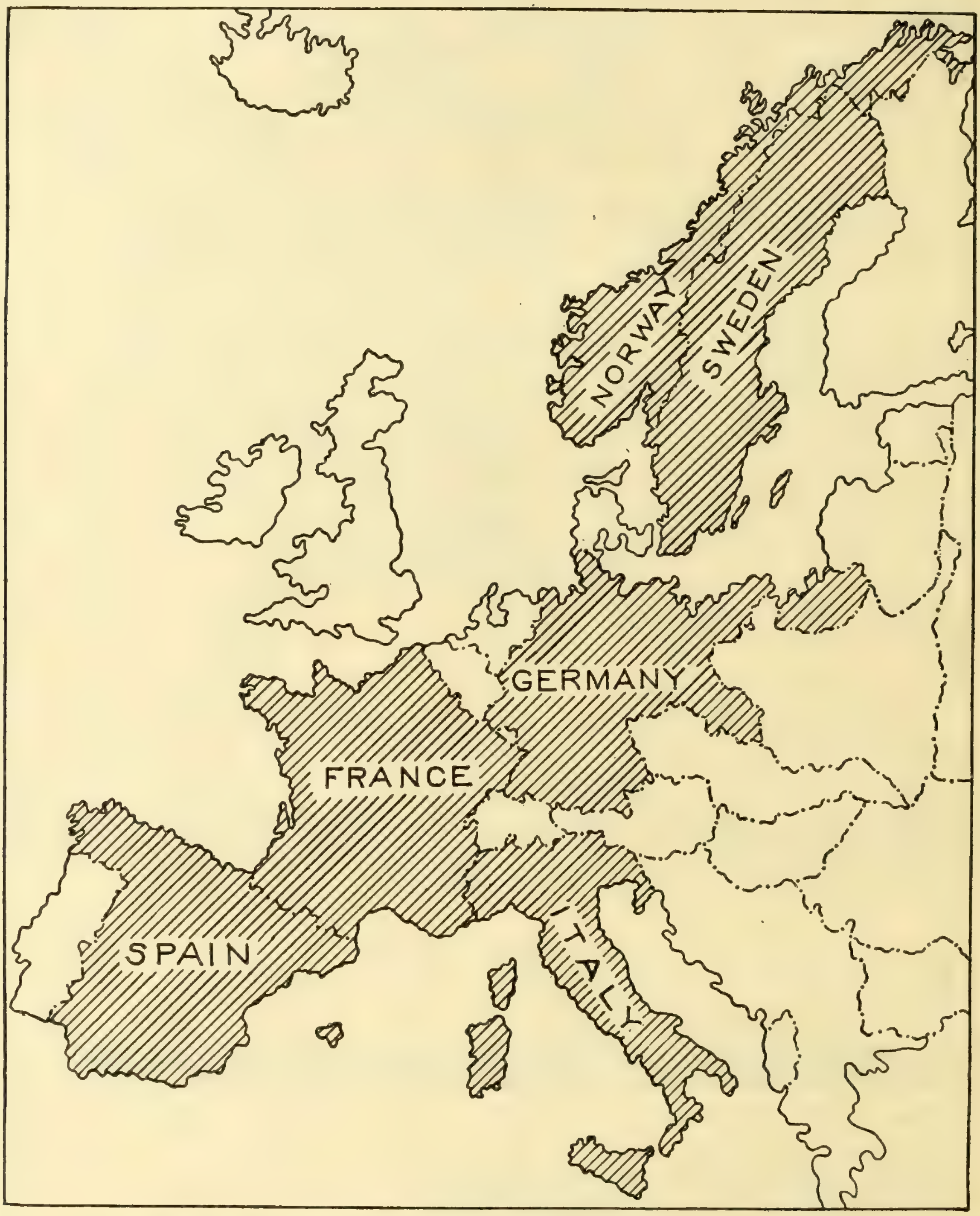

FIGURE 19.—The aggregate area of six of the principal nations of western Europe does not quite equal the total forest-land area of the United States.

If the objective of full forest-land use can be reached, it will be a major contribution to the entire national land use problem, and the solution of the latter is growing cause for grave national concern.

TO MEET NATIONAL REQUIREMENTS FOR FOREST PRODUCTS AND SERVICES

It is equally clear that the second major objective in the solution of our major forest problems should be to insure, if possible, supplies of timber and other forest products and byproducts and of watershed protection and other services adequate to meet national requirements.

If this objective can be reached, it will never be necessary to lower our standards of living or to retard our progress because ample and cheep supplies of the products and services of the forest are unavailable.

TO OBTAIN THE FULL ECONOMIC AND SOCIAL BENEFITS OF THE FOREST

The ultimate objective is to obtain all the benefits which productive forest land, the forest itself, and supplies of forest products and services adequate for requirements can separately and collectively render to our entire economic and social structure and to our national life.

TO MEET THESE OBJECTIVES REQUIRES NATIONAL PLANNING

LAISSEZ-FAIRE POLICY OF PRIVATE OWNERSHIP HAS NOT SUCCEEDED

Laissez-faire private effort, upon which the United States has largely depended up to the present time and which is avowedly planless from the national standpoint, has seriously deteriorated or destroyed the basic resources of timber, forage, and land almost universally. It has not concerned itself with the public welfare in protection of watersheds. It has felt little or no responsibility for the renewal of the resources on which its own industries must depend for continued existence and much less for the economic and social benefits growing out of the perpetuity of resources and industry. Even in fire protection, its most conspicuous constructive action, the public has largely carried the financial burden.

The record of the past sharply raises the question of how much further main dependence can and should be placed upon this policy to meet the major objectives specified.

The outstanding progress in American forestry to date has been where the public has taken things into its own hands in the ownership and management of lands, as for example, the national forests, or in the organization and leadership of such activities as protection against fire, or against such threats as the gypsy moth or the white pine blister rust.

These public efforts are, at bottom, first steps toward national planning. In any case, an expansion of public effort in the direction of national planning could hardly make a worse showing than has private ownership in either resource destruction or resource renewal.

THE LONG-TIME CHARACTER OF FORESTRY IN ITSELF REQUIRES NATIONAL PLANNING

The need for 80 to 150 years to grow high-grade material indicates the importance of the time element in forestry, but the fact that growth cannot be increased to current requirements much if any before the end of the present century is still more significant.

Furthermore, to obtain even these results will necessitate vastly increased efforts in practically all parts of the country, including such things as widespread, long-continued restraint in cutting over the entire East to build up growing stocks.

THE MAGNITUDE AND COST OF THE UNDERTAKING NECESSITATE NATIONAL PLANNING

Despite all efforts to date, total growth in our forests is only half the total drain, and growth of saw timber only one-fifth the drain. We still have millions of acres of devastated land and more millions of deteriorated forest. The processes of devastation and deterioration are continuing on a large scale.

It is obvious that millions of acres must be put under intensive forest management, the production of millions more increased by better methods of cutting and fire protection, millions of acres planted, the scale of research greatly increased, aid to private owners increased, and public ownership greatly enlarged.

It follows that both the magnitude and the cost of the programs required will be so great that they will necessitate the maximum possible effort of all agencies for years to come. They will also require the fullest possible coordination of these efforts.

Without national planning the necessary effort would be almost out of the question, and serious, costly, time-consuming mistakes would be inevitable.

THE IMPOSSIBILITY OF DOING EVERYTHING AT ONCE NECESSITATES NATIONAL PLANNING

Entirely aside from the inherent time element of growing timber, or at least that of high quality, all progress so far made in American forestry has been time consuming.

It has required 42 years from the setting aside of the first national forest from the public domain to acquire and put under administration the 157 million acres from this source. It has required 22 years to purchase 4,727,680 acres of national forests.

New York began in 1883 to build up its present holdings of 2,500,000 acres. The protection of private lands against fire has risen to 212 million acres as a result of 45 years of effort. It has required in the neighborhood of 30 years' effort by industrial owners to put approximately 2½ million acres under sustained yield management. Planting by all agencies has to date covered less than 2 million acres.

It follows that time must be reckoned with seriously; that everything cannot be done overnight; that progress must be made step by step; and in short that the time required to get things done emphasizes the need for national planning.

It seems conclusive, therefore, that national planning is absolutely necessary for meeting the three major objectives in the solution of our major forest problems, which can be summed up in one, to obtain the full economic and social benefits of the forest. National planning is so essential that it could itself be classed as a major objective.

THE REQUIRED ACTIVITY PROGRAMS IN A NATIONAL PLAN

The national plan recommended falls into two groups of programs, one of technical activities, which is outlined here, the other in the following subsection of the most effective agencies and means for carrying out these activities.

For clarity the areas already shown to be available for forestry in the United States are summarized in the following tabulation:

	Acres
Commercial forest land	494, 900, 000
Reserves, parks, etc	11, 000, 000
Noncommercial forest land	108, 700, 000
Abandoned agricultural land, etc	54, 700, 000
Total	669, 300, 000

Ordinarily in forest management the same area can be used for several purposes.

By far the largest areas are needed for timber production and watershed protection. The management and protection necessary for timber production will in most cases fully meet watershed and other requirements, although multiple use of the same area may often necessitate coordination.

The largest reservations needed for exclusive use are for recreation, but even here important services in watershed protection may often be rendered and a home furnished for wild life.

ADEQUATE PROVISION FOR TIMBER PRODUCTION

The area available for timber production is about 509 million acres:

		Acres
Total area of forest land		669, 300, 000
Noncommercial forest land	108, 700, 000	
Reserved for recreation, etc	52, 000, 000	
		160, 700, 000
Area available		508, 600, 000

THE AREA NEEDED AND THAT WHICH COULD BE USED FOR TIMBER PRODUCTION

Because of such factors as fertility, accessibility, and character of ownership, the management for timber production employed will probably vary from intensive practice designed to obtain the largest possible timber crops as a maximum to simple protection against fire as a minimum.

Full use of the land available for timber production might take about the following form:

	Acres
Intensive timber management	100, 000, 000
Extensive timber management	338, 900, 000
Simple protection on land relatively unfavorable for timber management	69, 700, 000
Total	508, 600, 000

This full land use, when fully effective 60 or 80 years hence, should be able to produce about 21½ billion cubic feet of timber in contrast with possible normal requirements of 16½ billion. In the large sawtimber class it would produce about 74 billion board feet as compared with possible normal requirements of 55 billion.

Unless, therefore, American requirements for timber increase, this plan would offer a substantial surplus for export. The existing conditions which indicate the probable availability of such a market have already been described.

A plan of land use, which with a reasonable margin of safety would approximately balance the national timber budget, is shown by the following tabulation:

	Acres
Intensive timber management	70, 000, 000
Extensive timber management	278, 900, 000
Simple protection on land relatively favorable for timber management	40, 700, 000
Simple protection on land relatively unfavorable for timber management	69, 700, 000
Total	459, 300, 000

By approximately the end of the century this adequate timber supply plan could be expected to produce about 17½ billion cubic feet and balance possible normal requirements with a margin of safety of 1 billion. Saw-timber production would reach about 60 billion board feet as compared with possible normal requirements of 55 billion.

This plan would leave about 50 million acres available for other purposes or as idle land:

	Acres
Denuded forest land	33, 500, 000
Unused agricultural land	15, 800, 000
Total	49, 300, 000

The various activities which are essential to both plans are so important that separate detailed consideration is necessary.

PROTECTION AGAINST FIRE

The following program for the control of forest fires covers all classes of forests for all forms of use rather than commercial forests for timber production only. It deals mainly with commercial forest land, but also with noncommercial forest chiefly valuable for watershed protection and grazing and of areas reserved for recreation.

The program is based in part on the certainty of occurrence of forest fires as a result of human occupancy and use. That fires are bound to occur is shown by a country-wide average of over 156,000 fires and of nearly 41½ million acres burned over annually in the 5-year period between 1926 and 1930.

In addition the program set-up has recognized the area needing but not now receiving protection, or 191 million acres, the difference between 512 and 321.

A further basis for the program is a determination of the allowable burn, or the percentage of the area by types that may burn over annually without impairing radically the forest values as determined by the predominant purpose of management.

An examination of how closely this objective has been reached under current expenditures affords still another criterion for the required program. Current annual expenditures for 1926 to 1930 of $5,437,598 on the national forests, including $1,780,840 capital investment in roads, etc., give a ratio of actual to allowable burn of 1.07 to 1, but an area of approximately 30 million acres on the Pacific coast and in the northern Rocky Mountains needs much more intensive protection to reduce a ratio of 5 to 1.

A ratio of nearly 11 to 1 on areas outside of the national forests shows that expenditures of $5,400,000 for 1927 to 1930 must be materially increased. Wholly unprotected areas, mostly in the South, are chiefly responsible for this high ratio, since on protected private and State forests for the entire country the ratio is 1.70 to 1.

Based upon these considerations, it is estimated that the ultimate cost of adequate fire protection on areas outside of the existing national forests will be nearly $20,000,000.

On the existing national forests $10,649,000 will be needed, of which $4,279,000 is current expenditures and the remainder capital investment.

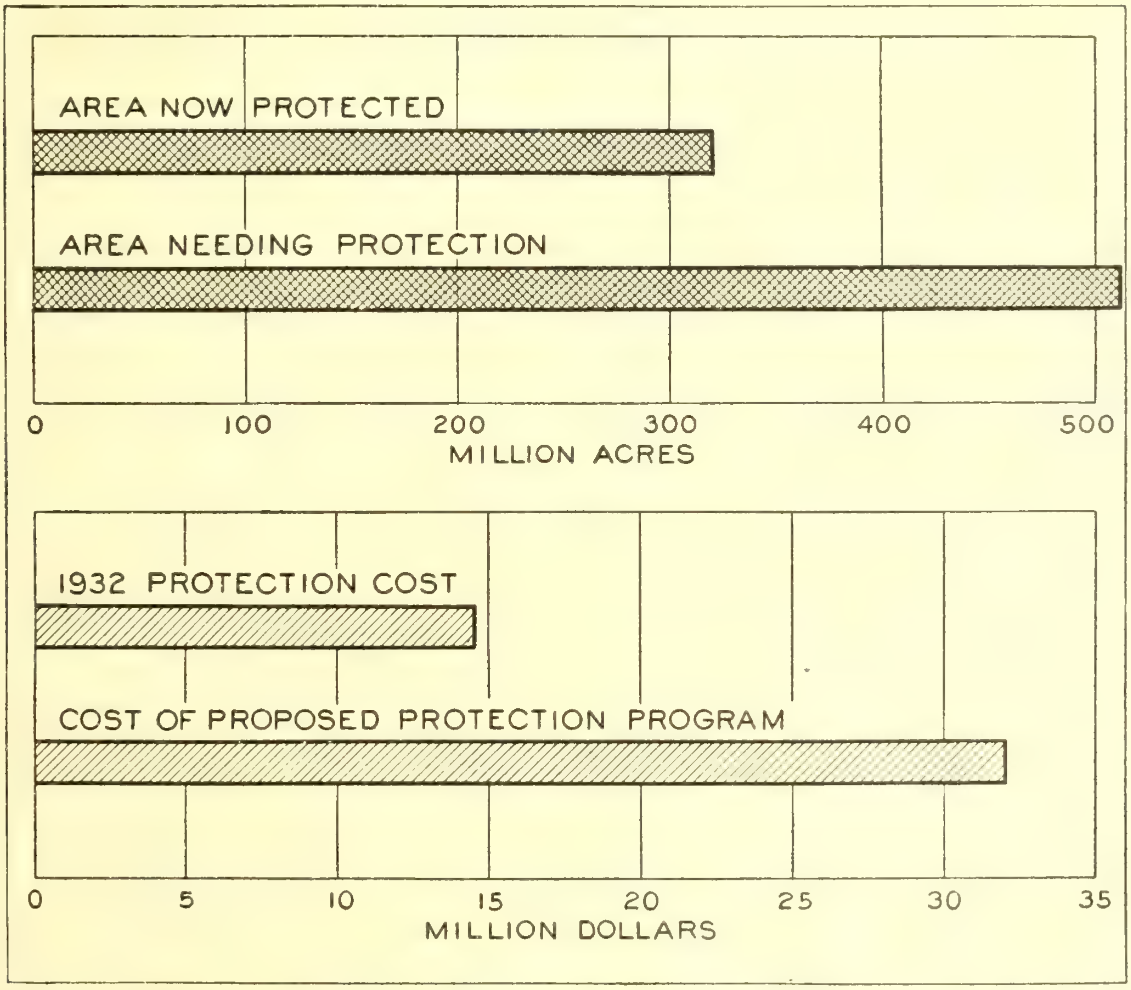

FIGURE 20.—A desirable standard of fire protection will require the enlargement of the area now under protection by 60 percent and the increase of 1932 expenditures by 120 percent.

An adequate program will also require the following increases:

	From—	To—
Indian forests	$94, 528. 00	$450, 000
Public domain	65, 333. 00	723, 598
National parks	95, 324. 85	159, 636

The total annual price which the American people will have to pay to control the scourge of forest fire is therefore about $32,000,000 as against 1932 expenditures of $14,475,000.

The area and financial aspects of the proposed program are also shown in figure 20.

PROTECTION AGAINST FOREST INSECTS

Insects cause losses in forest stands and in forest products estimated at over $100,000,000 annually. They lower timber yields and retard the growth of young stands. Frequently they change the composition of the forest to such an extent as to necessitate complete reshaping of management plans. They create serious forest-fire hazards. They damage or destroy finished wood products.

A well-organized detection and control system is essential to detect outbreaks of native insects in their early stages. The failure of some control projects has resulted from tardiness in recognizing an active infestation or from lack of complete information as to its virulence and extent. Costs in time and money are greatly increased unless control is begun promptly. Regional forest-insect surveys on a cooperative basis have been organized to meet needs but these have not been carried to the point where forests can be zoned according to susceptibility to insect infestation and the values that would be endangered by insect attack.

The cost to public agencies of a general detection and control system and of special control operations is estimated at $2,750,000 annually. This does not include needed private expenditures. Serious epidemics would require special provisions.

PROTECTION AGAINST FOREST DISEASES

Each of the many valuable tree species of the United States is subject to attack by one or more species of parasitic plants. Some of the great number are capable of killing trees, others merely injure them or destroy the wood they produce, and others retard their growth. Some attack the germinating seedling, others the mature tree. To identify the many different diseases that attack trees, to determine the cause of their spread or the conditions or management practices that affect it, and to ascertain what strains or varieties are resistant to them for even the 25 most important timber species, at the rate possible to the present force of investigators, would require not less than half a century.

Except for research, the outstanding need of forest pathology is a control service which will act in both a control and an advisory capacity.

The control campaigns now under way, particularly on the white pine blister rust in the East, and on the white and sugar pine forests of Idaho and California, should be carried to completion.

Measures for the control of forest diseases are mainly but not all indirect, consisting principally in modification of forest management. Actual disease-control work on private land can largely be handled by the owners of the land. Effective methods must, however, be based on a comprehensive knowledge of the influence of soil, climatic, and other factors on both the parasite and the host.

The dissemination of the knowledge which is available in several organizations including the Division of Blister Rust Control of the Bureau of Plant Industry requires an organization of experts. It would seem logical to expand the scope of this Division to include other forest-tree diseases.

Quarantines now established should be strengthened to prevent the introduction of further diseases, and interstate shipments, particularly between the East and West, should be watched to prevent native or introduced diseases prevalent in one region from becoming established in another.

The annual cost to public agencies of the program outlined is estimated at approximately $3,750,000. The largest item is $2,000,000 for white pine blister rust on the national forests which would be reduced to $300,000 after 5 years. As in the case of insects, special provision would be necessary for serious epidemics.

HOW TO STOP FOREST DEVASTATION

The fact that more than 60 million acres of forest land in the United States are already devastated fully justifies drastic action to prevent any increase. Even though the estimated further devastation of 850,000 acres each year may possibly be fully offset by the return of an equal area to productivity, the years of delay in the return and its high cost constitute whatever further justification may be needed for a program of preventive measures.

The major cause of forest devastation is fire and usually fire following cutting. The fire protection program outlined would alone go far toward stopping further devastation in most forest regions. It would also permit the gradual reforestation through natural process of much of the area already devastated.

Other measures needed on the greater part of the 9½ million acres now cut over annually without any conscious regard to the future of the forest are:

1. Preservation of young seedling growth already on the ground at the time of logging, or of the seed-bearing trees needed to reforest the land after logging.
2. Slash disposal by some form of controlled burning or other means on all areas where it constitutes a serious threat of destructive fires. Partial disposal may be one satisfactory alternative; special protection of cut-over land until the slash hazard is reduced is another.
3. In a comparatively few forest regions prevention or at least the careful control of grazing on reproducing areas will be necessary.

Aside from general fire protection, in the cost of which the public shares, these measures are not expensive.

Frequently the necessary seed trees can be cut only at a loss. Slash disposal will often more than justify itself from the standpoint of protecting remaining stands of timber. In many cases measures going considerably beyond those required to prevent forest devastation will be found to increase immediate profits rather than to reduce them. In fact in more cases than are realized forest lands can probably be devastated only at an immediate financial loss.

The total cost for the entire country, other than general fire protection, for stopping forest devastation, is estimated at not to exceed $6,000,000. If the full facts were available, the balance would probably be found to be on the other side of the ledger and in a much larger sum.

EXTENSIVE FOREST MANAGEMENT

Extensive forest management lies between the measures necessary to stop forest devastation and intensive forest management.

The data at hand do not permit an accurate determination of how much forest land in the United States now qualifies under this classification by reason of a growth rate resulting from conscious effort or otherwise. It may perhaps total 110 million acres.

This area as shown in figure 21 would have to be raised to about 279 million acres by about 2000 A.D. to meet timber requirements and to 339 million acres to insure full forest land use. The annual increase in the area brought under extensive management during the next 70 years would therefore have to be about 2½ or 3¼ million acres, depending upon the objective set up.

Extensive management would produce an average of about 42 cubic feet per acre annually, or two thirds of the full forest yield to be expected under intensive management. It represents a marked advance over the estimated current average growth of 21 cubic feet annually for the entire area of commercial forest land in the United States. The growth for individual types and regions would have to be increased from 50 to 200 percent.

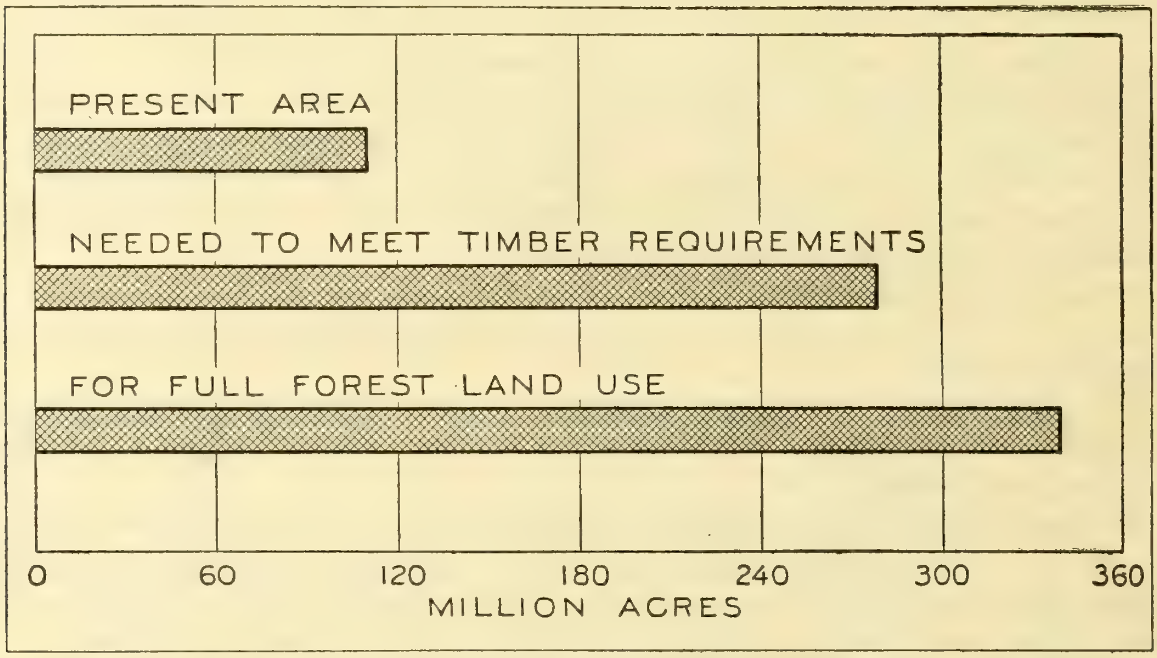

FIGURE 21.—To insure timber supplies adequate for national needs an area of 279 million acres should be placed under extensive management during the next few decades; and to insure full land use an area of 339 million acres.

Extensive management presupposes the levels of protection against fire, insects, and diseases already outlined. It uses relatively simple silvicultural methods such as the protection of advance reproduction, the leaving of at least the trees which cannot be cut with profit, additional seed trees where necessary, some attention to keeping the better species in the stand, slash disposal, and the prevention of injurious grazing. It places more emphasis on quantity than on quality of production. It attempts at least a rough application of the sustained yield principle. It would not ordinarily require planting or cultural measures in growing stands. It is characterized by a minimum of effort and low costs which may actually in most cases be found to be savings.

It may in some cases be a necessary first step to intensive forestry. Over large areas low in productivity or inaccessible to markets, it may be the most desirable ultimate practice.

INTENSIVE FOREST MANAGEMENT

Intensive forest management on 70 million acres is one of the measures needed to meet national timber requirements.

To bring the area available for timber growing into full productive use that under intensive management should be increased to 100 million acres.

To reach these objectives it will be necessary to expand the area under intensive management at the rate of about 1 or of 1½ million acres annually for about 70 years. The magnitude of the program is indicated graphically in figure 22.

The provision for intensive forest management is based on the theory that it is better to concentrate a substantial part of the effort in timber growing on the most favorable areas than to diffuse it over the entire area available.

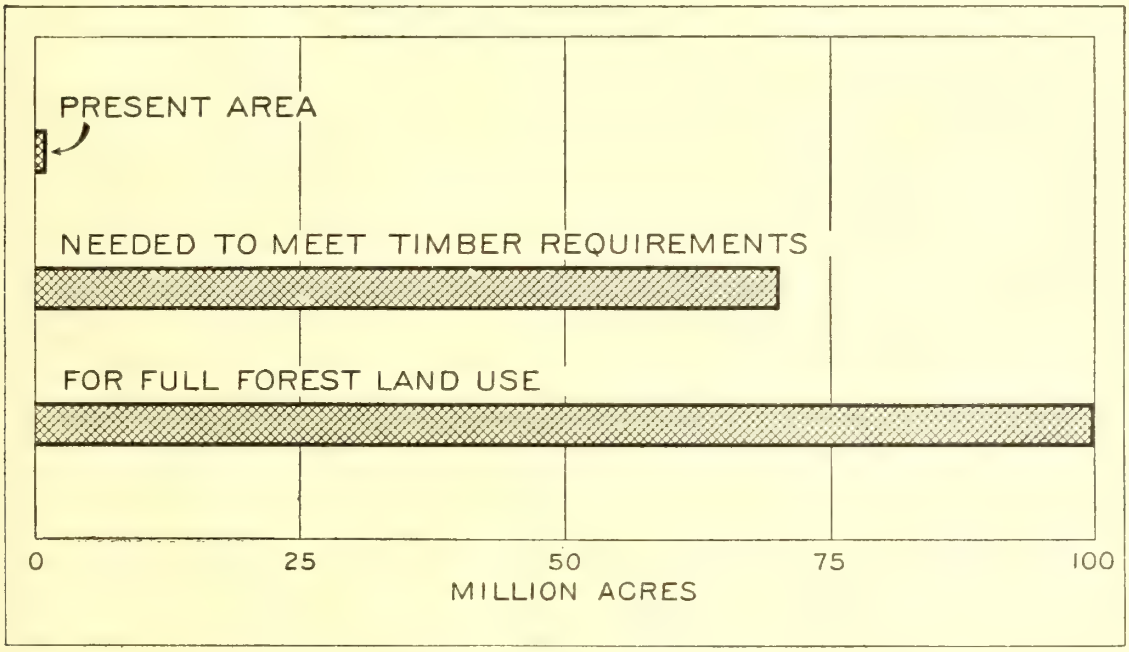

FIGURE 22.—The negligible area now under intensive forest management must be increased to 70 million acres to meet national timber needs. A program of full land use would place 100 million acres under intensive management.

Intensive forestry aims to realize through silvicultural treatment the nearest practical approach to the maximum productivity of a given site, or to grow by particular effort some special quality of product.

If the areas on which it is to be used are properly selected with reference to volume and value of production, accessibility to market, and risk, intensive forestry offers the promise of the highest volume, quality, and money return per unit of effort and cost. It offers the best means for producing the large-size, high-quality material and special products such as clear finish and flooring, which are likely to be scarce in the future and which are not likely to be produced without special effort.

It presupposes fire, insect, and disease control.

Under different conditions intensive forestry requires a wide variation in methods of cutting to insure natural reforestation of the best species. It requires cultural measures such as weeding, girdling, thinning, and pruning to carry young stands to maturity in the shortest possible time with the highest yields of desirable species and qualities. In some cases it is necessary to refrain from cutting in order to build up the forest capital essential to full growth. Planting is necessary where natural reforestation fails.

PLANTING

Although logically a part of intensive forestry, the area of barren land requiring planting is so large that a separate program is justified.

The area which must be considered for planting includes 83 million acres of nonstocked or poorly stocked forest land. It includes also 55 million acres of abandoned submarginal agricultural land, making a total of 138 million acres.

It is estimated that 47 million acres of this total will restock naturally within 20 years and 68 million within 40 years, leaving unstocked balances of 91 and 70 million acres, respectively.

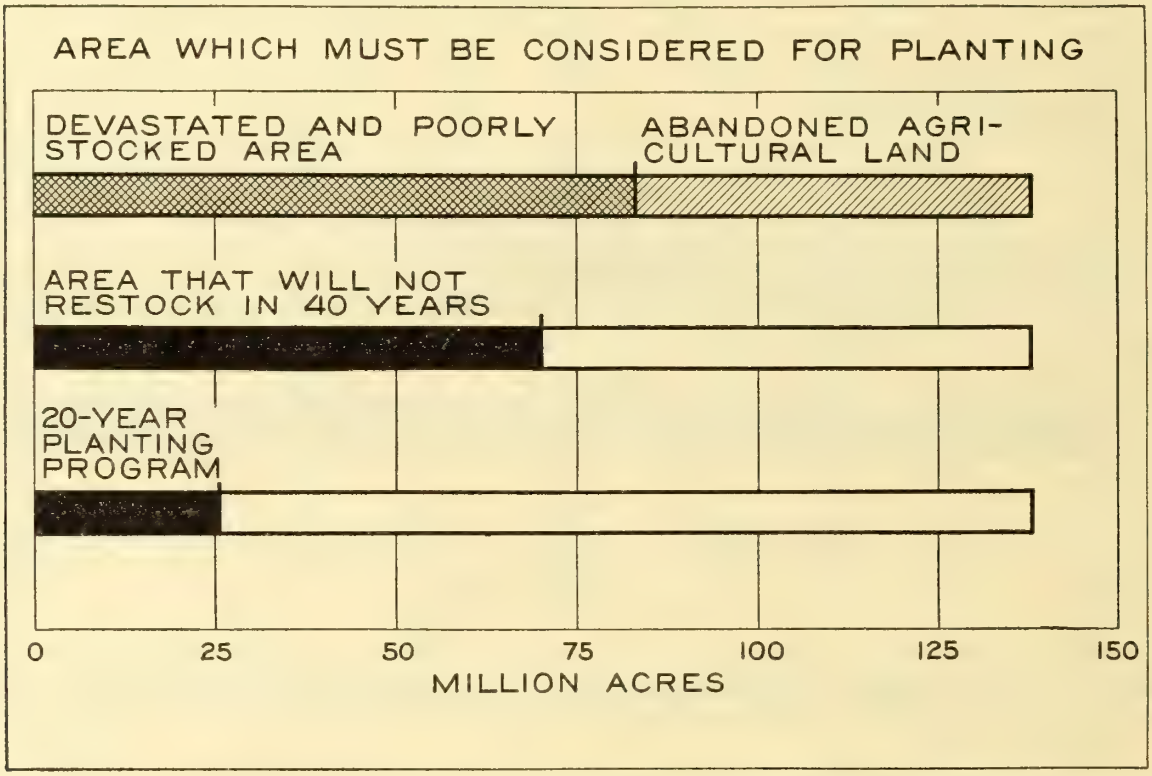

FIGURE 23.—Maximum planting possibilities are measured by 138 million acres of devastated and poorly-stocked forest and abandoned agricultural land. To provide for the planting, within 20 years, of even a scant fifth of this area represents a great advance in the current rate of planting. This program will, however, account for a substantial portion of the 70 million acres that would otherwise remain waste even after four decades.

The justifications for planting are those of forestry itself, timber production, erosion control and streamflow regulation, and in general the economic and social benefits of the productive forest.

Planting to date in the United States has covered 1,892,105 acres, including 153,460 in 1931. Large numbers of private owners, the Federal Government, States, and other public agencies have participated. While not uniformly successful, planting technique has improved steadily.

The 20-year planting program recommended is based on the most urgent watershed and timber production needs. It provides for 25 million acres, figure 23, nine tenths in the East. It would probably cost about $172,000,000, or an average of $8,600,000 for 1,276,000 acres annually.

Depending on the rate and extent of public acquisition, the public share of the total might be about 19.5 million acres, costing about $151,500,000. The private owners' share would be 5.5 million acres, costing $20,500,000.

ENLARGING THE CONSUMPTION OF FOREST PRODUCTS

In the United States until recent years wood has been the accepted material for a great variety of purposes and especially for general building construction.

Uses long held by wood are, however, being contested by old materials refined by science and by new materials of scientific origin promoted aggressively with the aid of intensive technical knowledge of their properties and the requirements for their use. Since 1907 there has been a declining trend in lumber markets. The use of wood for fuel has also decreased. The declines have not been offset by increased use for such purposes as pulp and paper.

The increasing interchangeability of materials may be expected to bring about the decreasing use of almost any material which attempts to rest its case solely on past importance.

The productive use of a large part of our forest land for timber growing is so important to the people of the United States that a balanced program in forestry must include aggressive and persistent efforts to retain, recapture, and expand markets for wood. Efforts of this kind offer in part at least the solution to such problems as the existing overproduction in the lumber industry.

A much fuller use in the future than in the past of the modern competitive methods followed for other materials is required. Accomplishments along four lines are necessary: lower costs to the consumer, increased satisfaction in use through fuller understanding of or improvements in properties, the development of new or modified products, and the promotion of use.

Among other things, greater industrial efficiency in logging, manufacture, distribution, and merchandising are involved. So also is the integration of forest industries.

Research can be made to contribute to most if not all of these ends through better understanding of the properties of wood and how they can be modified, and of how best to meet the requirements for exceedingly varied use. It can also contribute through the development of new and valuable products.

The distinct possibility that world markets in the future may be able to absorb any surplus, particularly of coniferous timber, that may be grown in the United States does not minimize the desirability or the necessity from the standpoint of the public interest if from no other, for keeping wood in effective competition with other materials in the United States.

ADEQUATE WATERSHED PROTECTION

Adequate watershed protection requires the improvement of various phases of land management, the details for most of which are outlined elsewhere. Such protection is particularly important on 308 million acres of forest estimated to exert a major watershed influence, and on the 141 million additional estimated to exert a moderate influence.

LAND MANAGEMENT

Among the most important improvements in management needed are protection against fire, which should be extended over 191 million acres additional and raised to the standards already indicated.

Methods of cutting timber must be improved at least to the extent necessary to prevent forest devastation and preferably to the requirements of extensive forestry.

About 11 million acres of devastated forest and abandoned submarginal agricultural land, almost entirely in the East, should be planted primarily to meet watershed requirements.

Range management must be begun on both privately owned forest ranges and those remaining on the public domain to build the forage cover up to normal density. Management must be brought to a higher degree of perfection on the national forests and Indian reservations. Artificial revegetation of some 900,000 acres at a cost of $3,000,000 is desirable. The requirements in range management are largely western.

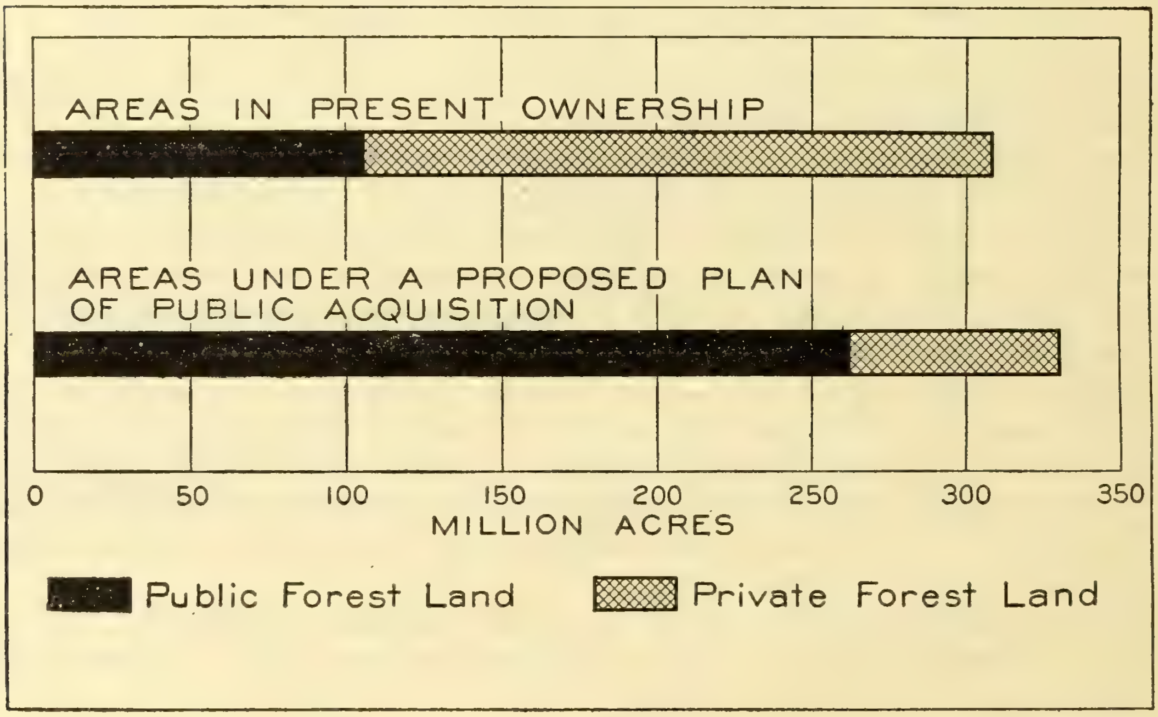

Figure 24.—Nearly all of the most critical watershed problems center in privately owned forest or abandoned agricultural lands of major watershed influence. A much larger public ownership is believed to be the only satisfactory solution.

Special measures, frequently of an engineering character, may be necessary as a last resort on perhaps 20 million acres mainly on abandoned agricultural land in the East, at a possible cost of about $20,000,000.

PUBLIC ACQUISITION

The watershed protection problem is largely one of privately owned lands. Since a substantial part of the benefits will accrue to the public and not to the landowner, necessary action on very large areas can hardly be obtained except through public ownership.

Public acquisition of 155 million acres of privately owned lands, three fourths in the East and including 22 million acres of abandoned agricultural land, is therefore recommended for this purpose alone. These lands are in forest areas having major or moderate influence on watershed protection. The proposed shift in ownership in the area of major influence is shown in figure 24.

The lands already under Federal, State, or other public ownership but without administration are a special case. In their present condition they are a public disgrace. Formal reservation as national or State forests or other units permitting administration is the first prerequisite to management and administration.

LANDS UNDER PRIVATE OWNERSHIP

The lands that remain in private ownership will be put in a much more satisfactory condition for watershed protection by the fire program recommended and this should be done with public aid. Further improvement depends largely upon the owner, although here also the public aid recommended in such ways as planting stock at low cost, advice, etc., will be helpful.

ADEQUATE PROVISION FOR FOREST RECREATION

The use of the forest for recreation has received so little attention and the need for it is and should be assuming such proportions that the first requirement is for a survey to determine what types of forest recreation are particularly desired and how much land should be set aside for each.

Although almost any forest may be used for recreation, the following types require especial consideration:

Superlative areas.—Those with unique scenic values so surpassing and stupendous in their beauty as to be of unusual interest and inspiration.

Primitive areas.—Tracts of old growth timber in which human activities has never upset the normal processes of nature.

Wilderness areas.—Those without permanent inhabitants or means of mechanical conveyance, and of sufficient size to permit a week or two of travel without crossing one's own tracks.

Roadside areas.—Timbered strips adjoining important roads.

Residence areas.—Those set aside for private homes, hotels, etc.

Campsite areas.—Those set aside for campers, etc.

Outing areas.—Those not seriously impaired scenically on which one can get away from the sounds of the highway.

For most or all of these it will be necessary to consider and provide in varying degree for such things as:

Finding suitable areas;

Setting them aside under suitable auspices, or for public purchase or acceptance as gifts;

Making suitable plans for their administration, including the enforcement of necessary regulations, the construction of needed roads and trails, or other forms of improvements, or the barring of roads and trails; planting; prohibition or restriction in timber cutting;

The elimination of billboards, etc., and objectionable private improvements such as buildings; and

Provision for protection against fire, insects, and fungi.

Federal, State, and local legislation and appropriations will be necessary. The most needed legislation may be congressional authorization to develop and safeguard the recreational, educational, and inspirational value of the national forests.

So far as can now be foreseen, the area which will probably be needed primarily for forest recreation, including 11 million acres already withdrawn from timber use, is:

	Acres
Superlative areas	3, 000, 000
Primeval areas	9, 500, 000
Wilderness areas	10, 000, 000
Roadside areas	4, 000, 000
Campsite areas	1, 500, 000
Residence areas	6, 000, 000
Outing areas	11, 000, 000
Total	45, 000, 000

ADEQUATE PROVISION FOR FOREST WILD LIFE

An adequate forest wild-life program must, among other things, obtain the best development and use of forest wild life as a product of the land in proper coordination with other products and services, make it possible for wild life to meet aesthetic, scientific, and other social services, and preserve the American hunting tradition. What is most needed to obtain these ends is forest wild-life management.

Upon suitable management depends the restoration and maintenance of wild life in a normal balance as between species and with other forest resources, distribution into proper environmental conditions, the preservation of species now threatened with extinction, and sustained yield of the wild-life crop, particularly of game and fur bearers.

The unification of wild-life and forest-land management is a second essential requirement of a program. Unification is made difficult by the fact that, in general, control of game is in the State while the ownership and control of the land and other forest resources with which wild-life management must be coordinated may be private or Federal as well as State.

Unification can be accomplished on privately owned lands by compensating the owner directly or indirectly for producing game crops.

On national forests and other Federally owned lands the working out of satisfactory arrangements constitutes an important but still unsolved problem.

The third requirement in a forest wild-life program is adequate provision for public hunting grounds. This requirement can be met by the program of public acquisition of forest lands recommended in another program.

Still another requirement is the establishment in all States of active nonpolitical game commissions with full authority to regulate seasons, bag limits, license fees, closed areas, and other phases of wild-life management.

The area of forest land in the United States is large enough fully to meet all wild life requirements.

The provisions needed in an adequate program for fish in forest waters are in general similar to those for mammals and birds in management, unification of control, public fishing grounds, and active nonpolitical game commissions with full authority.

A proposal of the Bureau of Fisheries for the expansion of a fishery survey begun in the western national forest regions requires special mention. One purpose is the development of a national policy for stocking national forest and other public domain waters.

Another needed measure is the coordination of the activities of the various agencies of the Federal, State, and local governments dealing with the fish problem into a general program.

ADEQUATE PROVISION FOR FOREST RANGES

The outstanding need for forest ranges is sustained yield management properly coordinated with the management of timber, watershed, wild life, and other forest resources.

For the ranges on the 190 million acres of privately owned commercial forest lands, the incentive is a return from grazing which in many instances can be made a material factor in meeting costs and increasing profits. Only coordinated sustained yield management, however, will insure the largest returns without interfering with timber production.

On noncommercial forest lands in private ownership of 38 million acres the range use may be dominant. Sustained yield management offers the only means for obtaining the largest continuous returns.

Watershed requirements will ordinarily but not always be met by thoroughly effective management for the timber and range resources. But satisfactory range management purely from the standpoint of continuous forage production is about as far as the unaided private owner can be expected to go.

Publicly owned or managed forest lands fall into two classes. One class includes the National and State forests and the Indian reservations. The need here is for perfecting management including the restoration of depleted ranges.

The second class includes the forest lands of the western public domain, 13 million acres of which, along with 9 million of interspersed nontimbered lands, should be added to the national forests and placed under management. The remainder, consisting of small, widely separated areas, usually parts of larger range areas, should be placed under a form of public administration which will assure satisfactory management.

ADEQUATE PROVISION FOR FOREST RESEARCH

Since lack of knowledge has handicapped the whole forestry movement, adequate provision for it is one of the essentials in a comprehensive national plan for the future development of forestry.

Such lack is one among the many factors which have led to the long series of mistakes in public and industrial policies which have created our most critical forest problems.

Such lack accentuated by the absence of traditional knowledge is one among the many factors which have delayed constructive remedial measures in growing and protecting timber, decreased their efficiency increased their cost, and discouraged efforts to put them into effect.

The building up of research has in practically all cases fallen seriously behind the creation and management of public forests and attempts to formulate State and national policies.

The great enlargement and intensification of the program recommended in this report for all phases of forestry in themselves demand a corresponding development of research by all agencies.

BY THE FEDERAL GOVERNMENT

Research in the Forest Service covers silviculture, forest management, and protection against fire, range management, erosion and streamflow, forest products, and forest economics including the Forest Survey.

Five years' development under the McSweeney-McNary Forest Research Act has shown the need for several modifications.

One of the most important is to double the authorization for annual expenditures of $250,000 in the Forest Survey in order to expedite its completion. National plans such as that presented here must of necessity be modified periodically to meet changing conditions. To help supply the data needed, provision should also be made for keeping important factual data current after the completion of the initial Survey.

The second is to add a section to the act which will place investigations of the crucial erosion-streamflow problem on the same footing as other forest research, and authorize annual expenditures of $500,000.

A third, which might if desirable, be incorporated in general legislation for all land, is to authorize a maximum annual expenditure of from $250,000 to $400,000 for the forest land part of land classification.

Under the research act thus amended the 10-year financial program of annual increases for all research in the Forest Service would start at $565,000 and end at $315,000.

Detailed estimates cannot be made satisfactorily for a longer period, although it is practically certain that unfilled needs will then necessitate further increases.

The Forest Research Act also provides for investigations in forest pathology in the Bureau of Plant Industry, in forest entomology in the Bureau of Entomology, in forest biology in the Biological Survey, and in forest fire weather research in the Weather Bureau. The need in all is to increase appropriations to the full amount of the authorizations by the fiscal year 1938. Increases for all this work would average about $100,000 annually. The need is also to provide for whatever emergencies may result from serious epidemics.

For research by the Bureau of Fisheries in connection with fish cultural operations in forest waters it is estimated that an annual appropriation of $25,000 will be needed.

The National Arboretum should also have a place in the Federal program because of the contribution which it can make to various fundamental problems. It would be of particular value because of the presence in Washington of so many scientific groups working on different phases of forest research.

BY THE STATES

Since forest research by the Federal Government must be concentrated on national and regional probelms and deal with only local problems only as they are required for the management of Federal lands, a large field must be covered by the States.

It is believed that the States would be justified during the next 10 years in building up their research from current annual expenditures of about $400,000 to $2,500,000.

BY ENDOWED INSTITUTIONS

Completely to meet the need for fundamental forest research and to round out the efforts of other agencies, the establishment of an institution devoted solely to forest research is most desirable. It could take the form of the single, closely-knit organization recommended by the

Society of American Foresters, or of several smaller units at university centers recommended by a committee of the National Academy of Sciences, or it could take the form of various combinations of the two plans. To be thoroughly effective it should command an annual income of at least $1,000,000.

A similar opportunity exists at endowed educational institutions and forest schools where annual expenditures of $500,000 will more nearly represent the potentialities for forest research than current efforts costing $120,000.

Existing endowed research institutions and arboreta could well contribute another $500,000.

BY THE FOREST INDUSTRIES

No program of forest research can be complete, however, without providing for an enlarged contribution from the forest industries. Research is one of the most effective competitive weapons at the disposal of the lumber and other forest industries to hold and to enlarge the consumption of their products. The public cannot and should not be expected to bear the entire burden. An increase to $3,500,000 in current expenditures of $2,500,000 is not unreasonable.

Present expenditures for forest research by all agencies and those proposed 10 years hence are therefore:

	Present	Proposed
Federal	$3,000,000	$6,000,000
State	400,000	2,500,000
Forest research institution		1,000,000
Endowed educational institutions	120,000	500,000
Endowed research institutions	230,000	500,000
The forest industries	2,500,000	3,500,000

THE REQUIRED AGENCY PROGRAMS IN A NATIONAL PLAN

THE ALTERNATIVES

Both public and private agencies are available for carrying out the activity programs outlined. The way in which these agencies can act may take various forms. The coordination of agency participation and form of action in a national plan leads into a second set of programs some of which are of great magnitude. The main agency form of action alternatives are:

1. Continued dependence on private ownership to carry the major portion of the national burden.
2. Primary dependence on private ownership, but using public aid to stimulate the necessary effort.
3. Primary dependence on private ownership, but requiring the necessary effort through public regulation.
4. Public assumption of a major part of the job through the ownership and management of the land.

Private ownership, private ownership stimulated by public aid, and/or by public regulation, and public ownership have all been tried out in the United States and all have made a sufficient contribution to American forestry and are so well established that they must be retained. All in fact center in ownership, so that the main decision narrows down to a choice between continued chief reliance on private ownership or a drastic shift to two kinds of public ownership, State and Federal.

The reasons for recommending a large shift to public ownership and the efforts which should be made to insure much fuller use in the future of the lands left in private ownership are treated in the following pages.

PRIVATE OWNERSHIP

The traditional American policy has been to depend upon private ownership and initiative. This is largely true in forest-land ownership and management despite the departure represented in the National, State, and other public forests.

ITS POSSIBILITIES AND LIMITATIONS

The possibilities and limitations of private effort must be judged in part from past results. These have already been outlined and need not be repeated. In general, however, they have been very seriously detrimental to the owners and the forest industries, to the productivity of the forest, and to the public interest. Constructive management is conspicuous largely by its absence, except in fire protection.

The results indicated are so universal that they raise the question if they are not almost inevitable in the system of private ownership particularly under American conditions and expectations for quick business turnover and large profits. The time element, uncertainties as to cost and markets, the absence of practical demonstrations, the lack of traditional knowledge, the general inertia or opposition to radical change in long-established ways of doing things, all contribute to the difficulties standing in the way of satisfactory private forestry.

Private forestry has the possibilities common to all forestry in the United States, the intrinsic value of wood as a raw material and the fact that it is renewable indefinitely, the exceptional number and value of American species, exceptionally favorable growth conditions, the largest domestic market in the world, regional demand larger than cut in all parts of the United States except the South and the Pacific Northwest, the same opportunities to fight for future markets as any raw material, the practical exhaustion of virgin timber supplies except in the Far West, the drain on our forest five times the growth for saw timber and twice the growth of timber of all sizes, a world demand at least holding its own and probably increasing, and, for coniferous timber most in demand, a world cut in excess of growth.

Finally, there is growing evidence that under many and perhaps most conditions it is more profitable even in immediate returns to leave forest land productive than to devastate it.

Private forestry has some distinct advantages over the public forests so far created. It has the best land and it has the opportunity to supply needed raw materials to perpetuate such enterprises as pulp and paper manufacture, to supply the wood needed in mining, and to diversify agriculture. In addition, there are whatever further advantages may lie in the greater efficiency claimed for private over publicly managed activities.

One obvious advantage which would accrue from fully adequate private effort would be the elimination of any necessity for further extension of public ownership and administration of land. Another might be the best possible outlet for private initiative; still another would be the largest possible tax base and hence tax returns to local governments.

The main public disadvantage is the lack of assurance either that the land will be utilized, that the needed forest products or necessary services of the forest will be supplied, or that the combined economic and social benefits from both will be realized.

Furthermore, the longer present trends continue the larger the area of devastated land and deteriorated forest will be and the greater the direct and indirect losses to the public, including the cost of restoration.

It is difficult to escape the conclusion that there is nothing in past experience or definitely in sight for the future which gives reason for hope that private ownership can be depended on for anything approaching the contribution to American forestry that has been expected of it during the past 20 years.

WHAT PRIVATE OWNERSHIP SHOULD DO

Under the program of public ownership proposed, 255 million acres of commercial land, including approximately 20 million acres of abandoned agricultural land, would remain in private ownership, in contrast with the 451 million acres of commercial forest land and abandoned agricultural land now held. About three fifths, or 155 million acres, would be in industrial ownership and 100 million in farm ownership.

Noncommercial forests in private ownership would be about 16 million acres instead of the present 45.

Private ownership would be relieved of much of its most acute problem such as the part caused by overload of forest land and timber.

The responsibility of private ownership would, however, be increased, not reduced. It would still hold over 46 percent of the commercial forest land, including abandoned agricultural land. This area must be depended upon for growing one half of the timber needed to meet national requirements.

It would involve as a minimum intensive management for timber production on about 40 million acres and extensive management on 150 million—areas far in excess of those now under such management—and standards of protection, silviculture, and sustained yield management much above those now in use. It would involve much greater and much more effective efforts to maintain and increase consumption of forest products.

Private ownership would still hold the responsibility for watershed protection on nearly one fifth of the area of forests of major influence.

To make the opportunities for private owners still more favorable and the assurance of constructive action more certain, public aid should be expanded in the ways which promise the largest results. The question of aid is discussed in detail on the following pages but must be referred to here to round out the picture. Judiciously used, public regulation could also be made to contribute to the same end.

Aid in protection against fire, insects, and disease should meet the public obligation in full. A fair share of the technical knowledge needed in the management of the timber and other forest resources should be obtained through research and made available through extension.

Financial obstacles, such as inequitable forest taxation, should be removed. If the necessary protection of the public interest through regulated and enforceable sustained yield management can be worked out, it might be possible to provide for loans and to allow mergers and the curtailment of production. This should strengthen the financial structure of the forest industries and help to stabilize ownership.

Increased public aid would in itself however, increase private responsibility for the productive use of the land held.

All in all, therefore, private ownership would still have ahead of it an enormous task and one which would require its maximum possible efforts.

PUBLIC AID TO PRIVATE OWNERS

ITS POSSIBILITIES AND LIMITATIONS

The granting of public aid to private owners of forest land has been in part an attempt to perpetuate the traditional American policy of private ownership by stimulating private initiative.

It is in part also a recognition of the public interest in land use, the production of timber and other products, and in the resulting economic and social benefits. This interest has local, State, regional, and national aspects.

Aid in fire protection recognized also a large public use of privately owned lands and great public indifference in the use of fire. It recognized outside risks beyond the control of individual owners. Finally, it recognized protection against fire as one of the main requirements in forestry for timber production or other purposes.

Aid in the control of forest insects and diseases recognized the highly specialized and variable technical problems involved, the very irregular occurrence of epidemics, as well as their State, regional, national, and even international aspects.

Aid in planting recognized the difficulty that small owners with periodical requirements experience in obtaining seedlings at reasonable cost. It recognized the widespread psychological appeal of planting and attempted to remove possible obstacles.

Advice in forest management attempted to offset the absence of traditional knowledge of methods of timber growing and the lack of practical demonstrations, and to overcome the inertia which handicaps an entirely new kind of enterprise.

Research attempted to recognize the handicaps indicated in the preceding paragraph, to build up a fund of knowledge and to have the public do what large numbers of small owners could not possibly do for themselves individually.

Taxation, either because of the existing form or of future uncertainties, has rightly or wrongly been held by private owners to be a primary obstacle to the development of forestry. Relief in many States has gone to the extreme of outright subsidy.

Aid began as early as 1876 in Federal research and in fire protection in New York in 1885. Marked development began in 1911 with Federal participation in fire protection, and was still further stimulated in 1924 with the passage of the Clarke-McNary Act, which brought in various other kinds of aid. The latter was in fact a carefully considered and publicly announced effort to try out on a large scale the efficiency of aid in stimulating private owners to shoulder the major part of the job of timber growing in the United States, before attempting Nation-wide regulation or greatly enlarged public ownership.

The first decision which must be faced lies, therefore, between three alternatives. Whether—

1. Because of the success of the trial of the public-aid plan or its future promise primary dependence for the major part of the forestry job should continue to be placed on private ownership stimulated by public aid, which would probably mean a very much larger public contribution; or

2. Because of the failure of the plan or the demonstrated limitations as to its future promise, public aid should be utilized only for greater assurance of the necessary constructive private action on greatly reduced private holdings. Public aid under this plan would be considerably smaller, even though the time required for public acquisition is taken fully into account; or

3. A possible third alternative of combining public aid with public regulation will be considered under the latter heading.

The decision between the first two alternatives has been anticipated in the discussion of private ownership.

While the public has obtained fully commensurate returns from the aid so far given, the detailed data already presented show the trial of the first alternative during the last 20 and particularly the last 10 years has not been entirely satisfactory.

Private owners accept aid but too rarely carry their own efforts farther.

The devastation of forest land continues on a large scale. The deterioration of forests continues on a much larger scale. Growing stock or forest capital is reduced, when both public and private interest require that it should be increased. These processes continue both on the cut-over lands of the East and in the virgin timber stands of the West. Watershed requirements are met only to the extent that partial protection against fire can meet them. Constructive measures of forest management and reforestation by planting lag far behind the destructive processes. Ownership seems to be tending toward less rather than greater stability.

Much of the Federal aid designed to reach the private owner is turned over to the States for administration. It has been a decided or the controlling factor in the stimulation and development of a forestry organization in at least half of the States, and of aid to the private owner in practically all of the 45 States and 2 Territories where it is now given.

The stimulus to State effort has been offset in part at least by the inability or unwillingness of the States to match Federal-aid ratios. This failure is often the most serious where the need is greatest, as for example, in the South.

In general, therefore, the conclusion is inescapable that with aid in the forms so far extended, even though guaranteed in much larger amounts, private ownership will fall far short of meeting national needs.

Enlargement of existing forms of aid will be worth while. New forms will be suggested which should be helpful. These are recommended, however, under the second alternative of obtaining better results on a much smaller area of private lands.

RECOMMENDED PUBLIC AID

Public aid may take the form of Federal and State and other public aid to private owners, or of aid from one public agency to another. The former will be given first consideration.

Undoubtedly there are definite limitations beyond which such aid cannot go without becoming outright subsidy and exceeding the public obligation and interest. It should not be carried into the pork-barrel category. The recommendations recognize these limitations as well as the factors justifying enlargement.

Protection against fire should as rapidly as possible be extended over forest lands now unprotected, amounting to at least 191 million acres. Standards should be raised over practically the entire country but chiefly in the South. To meet both the objectives on private and State lands, expenditures must ultimately be increased to about $20,000,000, as contrasted with $7,221,000 in 1931. A large part of the increase, from $900,000 to $11,000,000, is in the South. Because of the size of the increase in the South an intermediate southern objective of $6,000,000 has been recognized.

The ultimate Federal contribution in this program should be about $5,000,000. The amount of the State contribution will vary between 75 and 35 percent in individual cases, depending upon what is obtained from private owners.

For a general forest-insect detection and control system and for special control operations on private lands public expenditures of approximately $2,450,000 annually will be required, of which the Federal Government and the States should carry about equal parts. Private owners must contribute an indeterminate amount for actual control operations, depending upon such factors as the merchantability of trees cut.

For protection against very serious insect and disease epidemics no estimates can be made. Because of their infrequent occurrence and interstate or international character, emergency forces can best be directed by Federal agencies. The proper contribution of Federal, State, and private agencies will necessarily have to depend upon the conditions in each case.

The public contribution needed for a control service for both advisory and control work on forest diseases on private lands is estimated at about $1,410,000 annually, with the Federal Government and the States sharing about equally.

Planting stock should be made available at about one-half cost to all industrial and farm owners. The annual Federal contribution, now $79,960, need not exceed $350,000 and would be used for assistance in the establishment of new and the expansion of existing nurseries and the enlargement of technical staffs. The State contribution need not be larger.

In connection with a greatly enlarged planting program, provision is necessary for the certification of forest tree seed as to source and for seed testing. It need not cost more than $50,000 and should be handled by the central government.

While Federal forest research should be enlarged as previously recommended, it should not be extended beyond the Federal obligations already specified. Despite this limitation, the results will have important State and private-aid aspects.

Until the Federal Government has met its own obligations for research it is somewhat difficult to justify financial contributions for research on State and local problems, and the research required on local problems for the management of Federal lands can best be done by the National Government. All Federal and State work is of great value to private owners as well as in the administration of public forests. Federal expenditures will need to be increased by about $3,000,000 and State expenditures by about $2,100,000 during the next 10 years. The burden on the States will not be heavy, however, considering the number interested.

Advice in forest management is a form of aid urgently in need of enlargement and one to which both the Federal Government and the States should contribute.

Present Federal contributions in advice in farm woodland forestry of $69,850 should be increased as rapidly as possible to $250,000, and this should be matched by at least an equal amount by the States. Current State expenditures are $92,718.

Provision should also be made for similar aid to industrial owners. The Federal contributions should be $375,000, of which $150,000 would be available to match State contributions on a 50-50 basis and up to $225,000 for direct expenditure by the Federal Forest Service.

Forest taxation, a State and local function, should be placed on an equitable basis. The Federal Government should continue to assist in working out sound principles.

Other forms of possible public aid to private owners include loans, authorizations for mergers, and curtailment of output, which if allowed should be combined with regulatory requirements for sustained yield management which will protect the public interest. They will therefore be discussed under Public Regulation.

The second class of public aid includes possible aid from the Federal Government to States and from States to counties and other political subdivisions. Only the former will be discussed. Senate Resolution 175 asks particular consideration of the possibilities and desirability of Federal aid to States and implies use for the purchase of State forests.

That State action might be stimulated is recognized. But gifts are not recommended because, under the plan proposed, it is believed that the Federal Government will have about all the financial load it can carry, and because it is believed that the soundest principle is for any public agency to undertake only what it can subsequently finance. Efficiency in expenditures will be greater. Wealthy States do not need such aid. The poorer States would probably not be able without further aid to carry the forests thus acquired until self-sustaining. The wealthy States, which in the last analysis would provide the funds, might prefer to build up State forests within their own boundaries and have their contributions to Federal income go into Federally owned and managed lands, for which they would be able to watch expenditures and to demand an accounting.

Finally, Federal gifts to States for State forests would probably sooner or later lead to the political demand, as a flank attack on the conservation movement, that the existing national forests be turned over to the States.

Loans to States are subject to much the same objections. The uncertainty of repayment might well make nominal loans actual gifts.

Federal acquisition and administration of national forests have important aid aspects to State and local communities and private owners despite the fact that they were established and are administered primarily to meet national problems. It is estimated, for example, that the net annual gain to the States and counties between 1923 and 1927 from the national forests was approximately $10,000,000.

PUBLIC REGULATION

Most European and some other countries restrict the handling of privately owned forests. Nearly all provide at least for the classification and preservation of forests necessary for watershed protection, or for the protection of the public health, or for national defense. For such purposes the owners are subject to more or less strict control. Many countries provide that other forests at least be kept in a productive condition.

In the United States practically all the States have undertaken in varying degrees to restrict the use of private forest land, chiefly to prevent injury to other persons or property. The restrictions are mainly in the prevention, suppression, and use of fire and in the elimination of fire hazards. A few States have other restrictions. The regulation of other activities, both State and Federal, is widespread, including such things as the use of wild life, water resources, the use of urban land, methods of business competition, and combinations in restraint of trade.

The public unquestionably has the right to compel private owners to desist from practices which will directly injure others or the public in general or will destroy or impair the efficiency of forests for watershed purposes. It also has the right to protect itself against waste and social loss resulting from forest devastation even where watersheds are not involved. The right to compel the maintenance of high productivity by means of desirable standards of silvicultural practice is less well established.

The need for higher standards than could probably be compelled is unquestionable.

But if the private owner is to be regulated, the public should pay its fair share of the costs of measures intended largely or solely for the benefit of others than the owners.

ITS POSSIBILITIES AND LIMITATIONS

Since private ownership has in the past largely failed in meeting national requirements and offers little more promise for the future, and since public aid in any form yet proposed apparently has very definite limitations in its possibilities of accomplishment, something more is called for. Public regulation is one of the remaining possibilities.

Nation-wide regulation in which the Federal Government and all the forest-land States join forces for maximum effectiveness could certainly be counted on to give larger and more positive results than the combination of private ownership and public aid.

Theoretically, regulation should be effective in a much shorter time than large-scale public acquisition, the other major possibility remaining at our disposal.

Regulation promises substantial benefits to the owners themselves as well as to the public.

It should help to perpetuate the American philosophy of private property notwithstanding some curtailment in the right to utilize this property.

Of importance when taxation is such a serious burden, regulation, in at least its initial expenditures and discounting future direct returns, should cost the public somewhat less than public ownership.

But public regulation has limitations also which should be taken into account.

Since both Federal legislation and that of a large number of States would be required and might be strongly opposed, considerable time would probably be required to obtain the legislation alone. The additional time necessary to make regulation effective on the ground might give little or no advantage in time over public ownership.

The twilight zone between Federal and State effort might and probably would result in complications and weakness.

The opposition and financial weakness of private owners and the ease of defeating the enforcement of requirements on the ground might and probably would offer serious difficulties.

It would be impossible to regulate an owner who would not retain ownership, and this class might include much of the land most needing betterment.

The danger that the owners might gain control over the regulation machinery locally and nationally and use it in a way detrimental to the public interest cannot be entirely overlooked.

The best legal justification for regulation is perhaps for the protection of watersheds and for the prevention of forest devastation. Neither alone will build up forest capital or growing stock to keep forest lands fully productive and therefore fully meet national timber requirements.

Furthermore, the difficulty of obtaining legislation and of satisfactorily enforcing it might make it doubtful whether either watershed protection or the prevention of forest devastation could be fully secured for sometime to come.

The fact that regulation has largely failed in many of the States with even moderate statutory requirements, which are almost universally accepted as necessary, raises a question as to whether a Nation-wide extension would succeed.

If the principle of public aid on requirements intended largely or solely to benefit others is fully met, the cost to the public might fall so little below that of public acquisition that purchase would be preferable. Except for taxes, however, the public would under regulation get only the indirect and intangible returns and not the direct receipts which could be obtained from publicly owned lands.

All things considered, however, public regulation is one of the two possibilities which offer any real promise of meeting the major objectives set up.

THE PUBLIC REGULATION RECOMMENDED

The recommendation that chief reliance be placed on public ownership as the next major effort in American forestry eliminates Nation-wide public regulation, at least for the time being, except as a possible concurrent effort.

As a minimum, State legislation and enforcement of public regulation is desirable in the fields in which it has been most fully supported by public opinion, and should, therefore, be most enforceable. The outstanding example is in the use of fire and the elimination of fire hazards such as slash.

No discouragement should be offered to any State which desires to experiment in more comprehensive regulation.

One desirable form of extension which combines aid with regulation is that of loans. It is desirable that an effort be made in the near future to work out the possibility of loans under Federal auspices, with terms and requirements adapted to the needs of forest properties. To protect the public interest, such loans should in each instance be coupled with enforceable requirements for sustained yield management. Some such machinery as that now set up for farm loans by the Federal Farm Loan Board might be found feasible.

Still another possible extension might take the form of authorization for mergers and/or the curtailment of production, if coupled with provisions for the protection of the public interest through enforceable requirements for sustained-yield management. Although plans of this character might be worked out under State auspices, Federal authorization and control would probably in most instances be preferable. The most promising possibility may be in the Pacific Northwest, where such an arrangement, if feasible, might serve to prevent the depletion of the remaining forest capital and hence a serious future reduction in forest growth.

Both of these plans deserve serious study, that of loans as a general proposition, and that of mergers and curtailment with reference to specific conditions such as that indicated in the Northwest. Either or both may well be found to be in the interest of private owners as well as of the public.

While either or both could hardly be depended upon to bring about the rapid country-wide adoption of forestry by private owners which is necessary, they might result in stimulating an advance which would not otherwise take place.

It is possible also that the privilege of enlarged association activities might be coupled with desirable provisions for better land management.

The entire question of public regulation needs further study by both private and public agencies.

American private owners have ordinarily considered it inherently objectionable. But the preceding discussion of loans and mergers indicates that many of its aspects would be beneficial to them. Mandatory public requirements should be accompanied by enlarged public aid, a combination which would benefit both the private owner and the public. Beyond this is the probability that sustained yield management in many, if not most, cases would be far more profitable than devastation and deterioration.

From the public standpoint, regulation with the exceptions indicated could be held in reserve for possible future use in case public acquisition lagged so seriously behind the program recommended as to jeopardize the public interest, or in case of the continued failure of private owners to keep or to bring their lands into productivity.

PUBLIC OWNERSHIP

Public ownership is the only remaining alternative for chief reliance in meeting national requirements. To be thoroughly effective, however, public ownership would require a program of such proportions that it would rank among the largest that have ever been undertaken by the American people. But under normal conditions the American people have never allowed themselves to be frightened out of a necessary program by mere size and cost.

ITS POSSIBILITIES AND LIMITATIONS

Some of the more conspicuous limitations or objections to large-scale public ownership must in fairness be pointed out in connection with the recommendation for its adoption.

Both necessary legislation and actual acquisition, even though carried through at unprecedented rates, would require time, and the urgency of acquiring large areas to prevent further depletion of existing growing stocks and further forest devastation as well as to speed up forest restoration is very great.

Large public holdings would reduce the tax base and hence the revenue of local governmental units, despite the fact that some of this reduction would be apparent rather than real, as on lands now or likely to become delinquent. It would be necessary to replace tax income in amounts sufficient to maintain local governments in desirable form by some such device as the return of 25 percent of gross receipts to national-forest counties.

Where lands which are going out of agricultural use are involved, acquisition might tend to displace the agricultural population over considerable areas.

Large scale acquisition, although a continuation of established policies, would probably encounter opposition because of its magnitude.

The total cost would be high, and unless clearly recognized as a long-term capital investment and financed accordingly would encounter the prevailing opposition to increased current costs of government.

One of the chief justifications for main reliance on public ownership in the future rather than private ownership as in the past is the extent to which the most serious forest problems of today center in or have grown out of private ownership of forest lands.

That of unstable ownership.

That of forest devastation and deterioration and depreciated forest capital.

That of excessive investments, overproduction of forest products, and economic losses to the forest industries.

That of economic and social losses to the public.

That of the lag of constructive measures to keep forest lands productive.

That of balancing the national timber budget.

That of abandoned agricultural lands suitable only for timber growing.

That of the most critical watershed conditions.

And, finally, that of the largest part of the deteriorated western forest ranges.

All of this makes continued chief reliance on private lands exceedingly precarious, despite their much larger area and better quality.

A large shift from private to public ownership seems to be the only way to carry out such a program as planting 25 million acres in the next 20 years.

Or to increase the area under intensive forestry at from 1 to 1½ million acres annually to reach 70 or 100 million acres by the year 2000.

Or to increase the area under extensive forestry by 2½ to 3¼ million acres annually to reach 279 or 399 million.

Or to enlarge the area under protection by 191 million acres to a total of 512, and to raise the ratio of actual to allowable burn to something approaching 1 to 1.

Or on 308 million acres of major and an additional 141 million of moderate forest influence to obtain fully satisfactory watershed protection.

Or to obtain satisfactory conditions on the minimum of 45 million acres which should be set aside for forest recreation.

Public ownership seems, therefore, to offer the only assured means of reaching the major forestry objectives of full forest land use, adequate supplies of forest products, and the full economic and social benefits of both, and also to make it feasible to carry out anything approaching the national planning necessary.

So, in fact, it offers the only full opportunity for the continuation of private initiative.

High initial costs should eventually under good management be offset, and more than offset, by direct financial returns and large indirect returns. The enterprise should eventually be self-liquidating from the public standpoint.

The preceding considerations, primarily the lack of assurance of obtaining under private ownership the full results needed in the public interest, and the probability of costs under public regulation, even though successful, which would fall little below public ownership, make it conclusive that a large expansion in public ownership offers the greatest assurance of meeting the public interest at probably the lowest ultimate net cost.

THE PUBLIC OWNERSHIP RECOMMENDED

Such considerations seem fully to justify the recommendation that public ownership be increased by a total area of about 224 million acres.

Public ownership of noncommercial forest lands should be enlarged by slightly less than 30 million acres to 92, this primarily for watershed protection.

That of commercial forest lands should be enlarged to meet combined timber production, watershed protection, recreation, and general economic and social needs by about 194 million acres, including slightly less than 32 million acres of abandoned farm lands. This would mean public holdings of 293 million acres, or about three fifths instead of the present one fifth of the total area of commercial forest. (Figs. 25 and 26.)

Of the total area recommended 177 million acres are in the East and 47 million in the West.

Rapid exploitation of the remaining virgin stands is under way in the West. To prevent the repetition of the depletion of forest capital, which has been universal throughout the East under private ownership, public acquisition of at least 90 billion board feet is justified. Investments should be self-liquidating; wholly disregarding public losses, the cost of rehabilitation of wrecked forest land would be

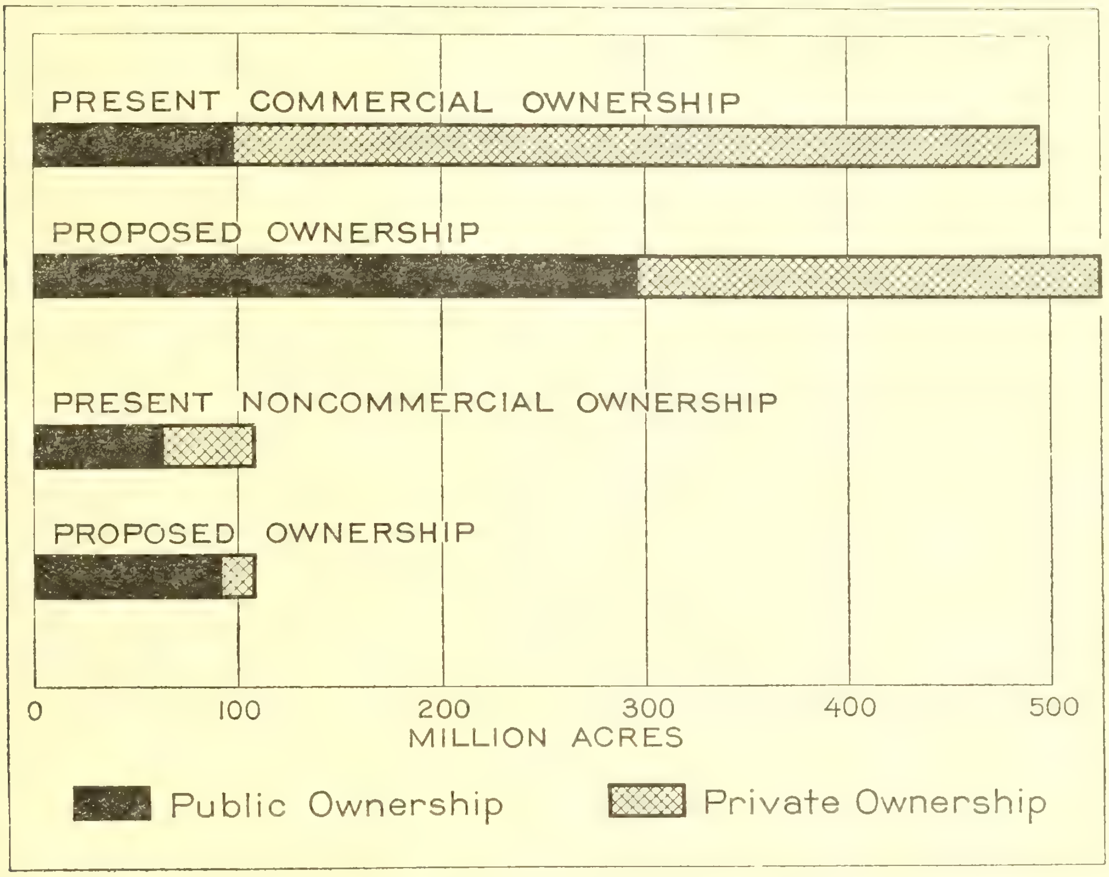

FIGURE 25.—Present and proposed ownership of commercial and noncommercial forest land. The increase in public ownership of commercial land from 99 to 293 million acres is to meet combined timber growing, watershed protection, recreation, and economic and social requirements.

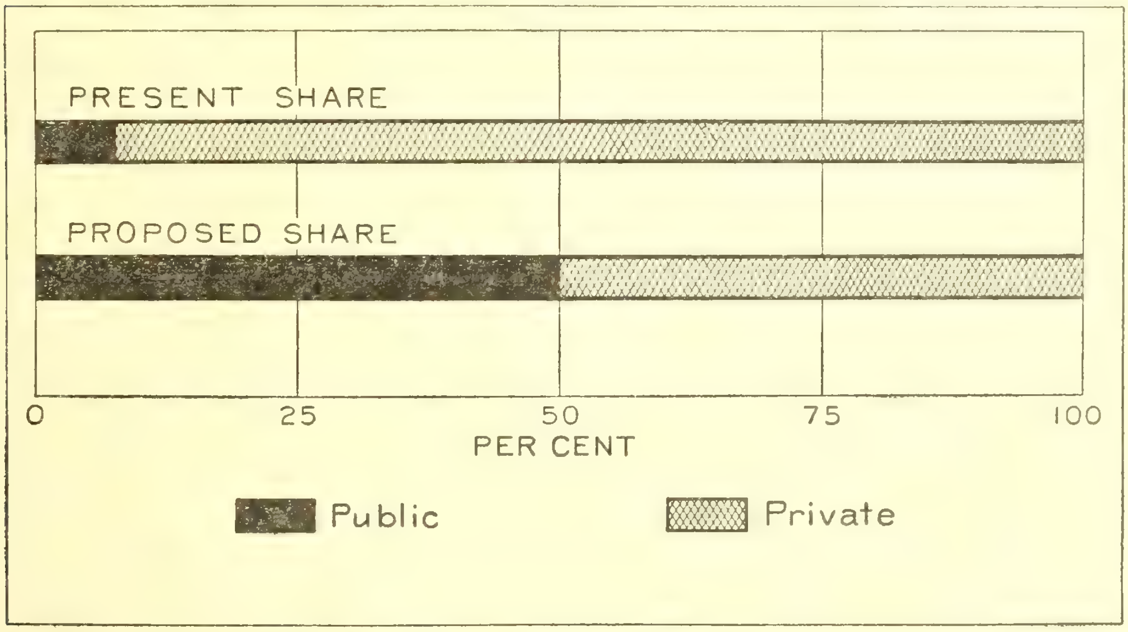

FIGURE 26.—The timber-growing job. The best assurance of meeting future timber requirements is for the public to take over a much larger share of the job than the present 10 percent or less. The area of commercial land recommended will make possible the half shown in the diagram.

much greater. This part of the task would probably fall primarily on the Federal Government.

The governing principle for the division of the task between the States and the Federal Government should be for the latter to take over only the part that the States and their political subdivisions cannot or will not carry.

On the assumption that the most wealthy States and their subdivisions will on the average be able to carry 80 percent of the full program and the least wealthy only 20 percent, about 40 percent, or 90 million acres, would be the States' share, and the remainder, or 134 million acres, the Federal share.

The cost of the total acquisition program will be materially influenced by the area acquired by tax reversion, the way in which the program is handled, and the prices paid for the land purchased. It may amount to as much as $750,000,000, two thirds of which would fall upon the Federal Government.

Even under normal conditions an early start and the most rapid possible consummation of the program would be justified to prevent further forest devastation and the deterioration and their inevitable results and to start the process of rehabilitation.

The depression makes such action much more urgent to relieve serious unemployment. The depression has made the national-land problem much more acute, and thus emphasized the need for making forest-land use contribute as fully and as soon as possible to its solution. Present prices of land and timber would also greatly reduce the total cost of acquisition.

It is believed both possible and desirable for the Federal Government at least to acquire cut-over land at the rate of 5 percent, or about 7 million acres a year, and western stumpage at the rate of about 9 billion board feet over a 10-year period. The yearly cost to the Federal Government for the first 10-year period would average about $30,000,000.

The time is ripe and the entire situation calls for an acquisition movement equal in aggressiveness but greater in magnitude than that which characterized the building up of the national forests from the public domain from 1905 to 1910. The Federal Government and most of the States must participate to make it a success.

It should be the next great step in American forestry.

With the acquisition of the land public obligations will only begin. The real task is to make them productive. The intensity of public effort on both lands now held and those to be acquired must be greatly increased to offset what has not been done by private effort.

THE COST OF THE NATIONAL PLAN AND HOW IT COULD BE FINANCED

Expenditures for all forest activities in the United States in 1932 as previously indicated totaled about $43,475,000. Of this amount about $24,375,000 was expended by the Forest Service, $2,600,000 by other Federal agencies, and $10,650,000 by State and other public agencies. Quasi public and private agencies spent about $5,860,000.

THE COST OF THE PUBLIC PROGRAM

The most important steps in the public program call for increased State and Federal effort in (1) enlarging and (2) managing public forests and (3) strengthening public aid and research.

TOTAL COSTS

The estimated total average annual expenditures required by State and local governments, the Federal Government, and by all public agencies to carry out the program recommended are given in table 1. Subsequent expenditures in all cases would be maintained at the rate of the fourth period.

COSTS SUBDIVIDED

Table 2 shows what the State and local money would be used for.

TABLE 1.—*Total average annual expenditures by all public agencies to carry out program recommended*

Period	State and local governments	Federal	All public
First 5-year period	$32,900,000	$83,800,000	$116,700,000
Second 5-year period	47,600,000	95,100,000	142,700,000
Third 5-year period	45,300,000	64,400,000	109,700,000
Fourth 5-year period	38,300,000	55,700,000	94,000,000

TABLE 2.—*Distribution of average annual expenditures for State and local forests*

Period	Acquisition and management of existing and new forests [1]		Other State activities, aid, research, etc.
	Total	Capital investment	
First 5-year period	$24,200,000	$21,800,000	$8,700,000
Second 5-year period	35,600,000	31,200,000	12,000,000

[1] Total area 100 million acres.

Similar estimates in table 3 give the distribution of Federal expenditures on the 317 million acres of present and proposed national forests and for other Federal activities:

TABLE 3.—*Distribution of average annual Federal expenditures on existing and new national forests and other Federal forest activities*

Period	Forest service					All other Federal activities [3]
	Existing national forests [1]		New national forests [2]		All other activities, aid research, etc.	
	Total	Capital investment	Total	Capital investment		
First 5-year period	$25,500,000	$17,200,000	$46,900,000	$42,900,000	$7,100,000	$4,200,000
Second 5-year period	22,900,000	14,300,000	60,200,000	51,400,000	9,200,000	[5] 2,900,000
Third 5-year period	13,100,000	4,500,000	44,800,000	32,800,000	[4] 4,700,000	[6] 1,700,000
Fourth 5-year period	13,100,000	4,500,000	36,200,000	22,000,000	[4] 4,700,000	[6] 1,700,000

[1] Management and protection on 161 million acres.

[2] Acquisition of 134 million acres and management on 156 million acres.

[3] Protection of parks, Indian lands, etc., aid, and research.

[4] Does not include research expenditures which are estimated for the first 10 years only.

[5] Does not include Bureau of Plant Industry expenditures which are only estimated for 5 years.

[6] Does not include estimates for Indian reservation and national park forests, expenditures for which are estimated for the first 10 years only, and Bureau of Plant Industry expenditures which are estimated for 5 years.

That the proposed expenditures are largely for capital investment in extending, improving, and making productive publicly owned municipal, State, and national forests is shown by the following tabulation of percentages of capital investment of gross charges:

	Percent
First 5-year period	71
Second 5-year period	68
Third 5-year period	57
Fourth 5-year period	44

The proposed capital investments may be further segregated into two categories, (1) land acquisition, (2) improvements such as physical plant, roads and trails, and cultural operations including such items as planting, stand betterment, insect and disease control, etc., as shown in table 4:

TABLE 4.—*Distribution of average annual capital investment in Federal, State, and local forest land by 5-year periods*

NATIONAL FORESTS, EXISTING AND ENLARGED

Categories	First period	Second period	Third period	Fourth period
Purchase of land	$29,500,000	$29,500,000	$19,500,000	$19,500,000
Improvements, roads, trails, cultural operations, planting, stand betterment, etc	30,700,000	36,200,000	17,800,000	6,900,000
Total	60,200,000	65,700,000	37,300,000	26,400,000

STATE AND LOCAL FORESTS, EXISTING AND ENLARGED

Categories	First period	Second period	Third period	Fourth period
Purchase of land	$12,800,000	$12,800,000	$12,800,000	$12,800,000
Improvements, roads, trails, cultural operations, planting, stand betterment, etc	9,000,000	18,400,000	12,300,000	2,100,000
Total	21,800,000	31,200,000	25,100,000	14,900,000

THE COST OF THE PRIVATE PROGRAM

Because of the large number of private owners of forest land, an estimate of the total cost of the private program would be meaningless. Furthermore, only meager data are available as a basis for such an estimate.

Costs will vary from the farm wood lot requiring only incidental time from the owner and no cash outlay, to the areas under intensive management. The latter may vary in different parts of the country and under different conditions, from 35 cents to $1.15 per acre annually.

In timber management, however, apparent costs may be actual savings. In most cases satisfactory returns cannot be expected without corresponding expenditures.

HOW THE PROGRAMS COULD BE FINANCED

An important factor in the consideration of how the program outlined could be financed is the possible income from managed forest lands.

THE POSSIBLE INCOME FROM MANAGED FOREST LANDS

In forecasting possible income a situation different from that now existing must be visualized. Over rapid exploitation of virgin timber rather than continuous production of organized forest properties, has created a false impression that timber supplies are still abundant.

The reduction of the growing stock for the entire East far below that necessary for full productivity and a current rate of growth well below market requirements indicate that whenever most forests are placed on a sustained yield basis the market condition will be one of scarcity rather than of surplus. The time when these favorable market conditions will occur depends in part on the rate of abandonment of the liquidation policy, or if it is not abandoned, when liquidation of the major portion of private holdings is completed.

Owing to uncertainties such as this no accurate forecasts can be made of the time when full financial returns can be obtained from timber management. In some favorably situated forests these returns can be realized quickly without waiting for cessation of the liquidation process. In forests still endowed with growing stock, the returns might be realized within 20 to 40 years. But areas devoid of growing stock cannot be brought to full productivity in less than 50 to 80 years.

Estimated returns from timber management are based primarily on the stumpage values of 1928 to 1930. Regional growth, acreages of intensive and extensive timber management, the distribution of production to private, State, and Federal activity are those set up for the purposes of this report.

The possible gross financial returns from a timber management program to produce 17 to 18 billion cubic feet annually, not including returns from logging, manufacturing, etc., are shown in table 5. Possible returns for grazing, recreational, and other uses are also shown. For public forests a conservative estimate is included for recreational use and watershed management based on the principle that the chief beneficiaries should bear a commensurate part of the cost.

TABLE 5.—*Estimated possible annual returns from Federal, State and local, public and private timber management and other forest uses and services*

Use of service	From private forest lands		From State and local public land		From Federal land	
	Area	Return	Area	Return	Area	Return
	Acres		*Acres*		*Acres*	
Intensive timber management	40, 000, 000	$140,000,000	10, 000, 000	$24, 000, 000	20, 000, 000	$50, 000, 000
Extensive timber management	150, 000, 000	300,000,000	35, 000, 000	30, 000, 000	90, 000, 000	84, 000, 000
Grazing, recreational, and other uses		50,000,000		10, 000, 000		26, 000, 000
Total		490,000,000		64, 000, 000		160, 000, 000

These possible rates of income from a fully restored and productive forest resource would permit ample expenditures for forest protection and other production costs and still leave net returns well in excess of $400,000,000 to $500,000,000 annually.

Such returns indicate a capital value of $10,000,000,000 or more for the forests, not including the large manufacturing and other dependent industrial values, as a permanent part of the Nation's natural resource wealth.

THE FINANCING OF CURRENT AND CAPITAL EXPENSES

The expenditures needed to carry out the program outlined, whether public or private, fall into two classes which suggest different methods of financing.

The first is current expenditures for carrying on everyday productive business such as costs of fire protection and of logging and milling.

The second is capital investments such as the purchase of additional land, planting, and road construction for increasing the capital assets.

The logical way for private owners to meet current expenditures is from current income from surplus, or from working capital borrowed on short-time loans anticipating current income.

For public agencies the logical way to meet current expenditures is by appropriations from actual or expected Treasury income or if necessary short-term borrowing.

For capital investments for Federal and State forests, long-term loans at a low rate of interest would afford the means for underwriting desirable projects beyond the immediate capacity of Treasury income.

Capital investments for private owners might be carried very advantageously under some such plan as that proposed for the enlarged field of the Federal Farm Loan Board.

THE MOST IMPORTANT LEGISLATION REQUIRED

BY THE STATES

The most important legislation required by the States to carry out the national plan and programs recommended will include laws—

Establishing State forest organizations where they do not exist, and strengthening those which are now handicapped by uncertainty of civil-service tenure or by political interference.

Establishing programs on a long-time basis both for the acquisition of lands as State forests and parks, and also wherever desirable for the management and administration of both existing and acquired lands.

Clearing up the status of tax-reverted forest lands, or submarginal agricultural lands suitable only for forests, accepting the inevitability of public ownership, providing for blocking into State or local forests those suitable for public ownership, and providing for their management and administration.

Similar laws for other State forest lands now in uncertain status.

Authorizing Federal acquisition by purchase or otherwise for national forests where desirable or necessary and not already provided.

Providing for State-wide organizations for fire control.

Strengthening existing regulatory forest fire laws by providing reasonable safeguards for the legitimate use of fire, and with provision for the punishment of carelessness, neglect, or arson.

Providing for the necessary protection of forests against damage from insects, diseases, acts of trespass and other injury, or where necessary in the public interest for the regulation of management.

Providing for the equitable taxation of forest land.

BY THE FEDERAL GOVERNMENT

The most necessary Federal legislation to carry out the programs recommended in the national plan will include—

- An authorization bill to put on a long-time program basis—
  1. The acquisition program.
  2. The appropriations necessary for the management and administration, protection, and development of the existing and proposed national forests, if further consideration shows such an authorization to be desirable.
- Authorizing acquisition of private land through exchange within 6 miles of the boundaries of the existing national forests.
- Adding about 22 million acres of public domain to the national forests.
- Recognizing recreation as a major national forest use as provided in H.R. 58, Seventy-third Congress.
- Modifying the McSweeney-McNary Forest Research Act—
  1. Increasing the annual authorization for the Forest Survey to $500,000, and including a supplemental authorization of $200,000 for keeping data current after the completion of the initial survey.
  2. By the addition of a section providing for erosion-stream-flow investigations with an annual authorization of $500,000.
  3. By the addition of a section providing for work on the forest-land phase of land classification, unless it later proves more desirable to provide for it in general land classification legislation; and including an annual authorization of from $250,000 to $400,000.
- Modifying the Clarke-McNary Act to authorize Federal expenditures, in cooperation with the States, of—
  1. Not to exceed $5,000,000 annually in forest-fire cooperation instead of $2,500,000 as at present.
  2. Not to exceed $350,000 annually to furnish forest tree seedlings to all classes of owners instead of the present $100,000 to furnish them only to farmers; also $50,000 for a Federal seed testing and certification station.
  3. Not to exceed $250,000 annually instead of $100,000 in farm woodlot extension.
  4. Not to exceed $375,000 annually in advice on forest management to industrial owners, $150,000 of which would be available for cooperation with the States.
  5. Not to exceed $250,000 in the control of insect attacks.
- Authorization to the Bureau of Plant Industry, through its Blister Rust Division, to cooperate in the control of forest diseases, other than the white pine blister rust.
- Authorization to the Secretaries of Agriculture and Commerce to provide expert assistance, and to cooperate with other agencies in wild life and fish activities and in developing a Nation-wide program of game conservation. Such legislation is embodied in S. 263, Seventy-second Congress.

THE ESSENCE OF THE NATIONAL PLAN

One of the most important aspects in the history of American forestry during the last 20 years has been a trial on a large scale of the relative effectiveness of private and of public forest-land ownership.

Private ownership has held four fifths of our commercial forest land with from 90 percent or even more of the total potential timber growing capacity. It has held the agricultural land which is being abandoned. It has also held two fifths of the noncommercial forest land. Practically all of the major forest problems of today have grown out of this ownership. As measured by expenditures only about 10 percent of the constructive effort in American forestry is being made by it. Nearly half of this effort is so remote as to have little or no influence on the forest itself. Sustained yield management would probably have yielded higher profits to the owners under many if not most conditions than forest devastation and deterioration. Private ownership has had the benefit of substantial if not wholly adequate public aid. It has also had the benefit of regulatory laws, chiefly protection against fire.

Public ownership, mainly in the national forests and State forests, has held three fifths of the noncommercial but only one fifth of the commercial forests. It has been characterized by the administration of the forest resource in the public interest and by the adoption of the principle of fully coordinated sustained yield management of the different elements of the forest resource. It has won its way through public condemnation to general public recognition and approval.

As measured by expenditures the public contribution represents nearly 90 percent of the total constructive effort by all agencies to the solution of the forest problem, and two thirds of this has been concentrated on the relatively small part of the land which the public has owned.

The effort on the public forests still falls short of what is needed. From the standpoint of national coordination, however, the concentration of the major part of the constructive effort on a relatively small part of the poorer land in public ownership and the concentration of a large part of the better land in private holdings which receive only a relatively small part of the constructive effort, shows a critical lack of balance. (Fig. 27.)

The plan recommended must go as far as feasible in attempting to correct this lack of balance. No national plan based on realities can do otherwise than take the results of the trial of the two forms of ownership seriously into account. The essence of the plan recommended is, therefore, in part, that the public should in the shortest possible time take over at least half of the national enterprise in forestry.

More specifically this would mean—

Slightly more than half of the commercial forest land.
Half of the timber-growing job.
Five sixths of the noncommercial forest land.
Three fifths of the forest ranges.
Four fifths of the area of major influence on watershed protection.
Eight ninths of the areas to be set aside for forest recreation.

These relationships are also expressed graphically in figure 28.

This recommendation would still leave to private ownership much more of an undertaking than it has yet faced, under conditions even more favorable for its success than in the past, with increased public aid, and hence with far greater responsibility.

The ultimate public holdings of forest land, totaling 393,000,000 acres, would be divided between the Federal Government and the States in about a 3 to 1 ratio.

On this modified distribution of ownership as a foundation falls the task and the responsibility of building a superstructure of the activity programs which constitute an essential part of the national plan. These programs cover the entire range of the management, protection, and administration of the timber, watershed, recreational, wild life, forage, and other resources which make up the forest, and are designed to make the forest meet the objective set up of full economic and social service.

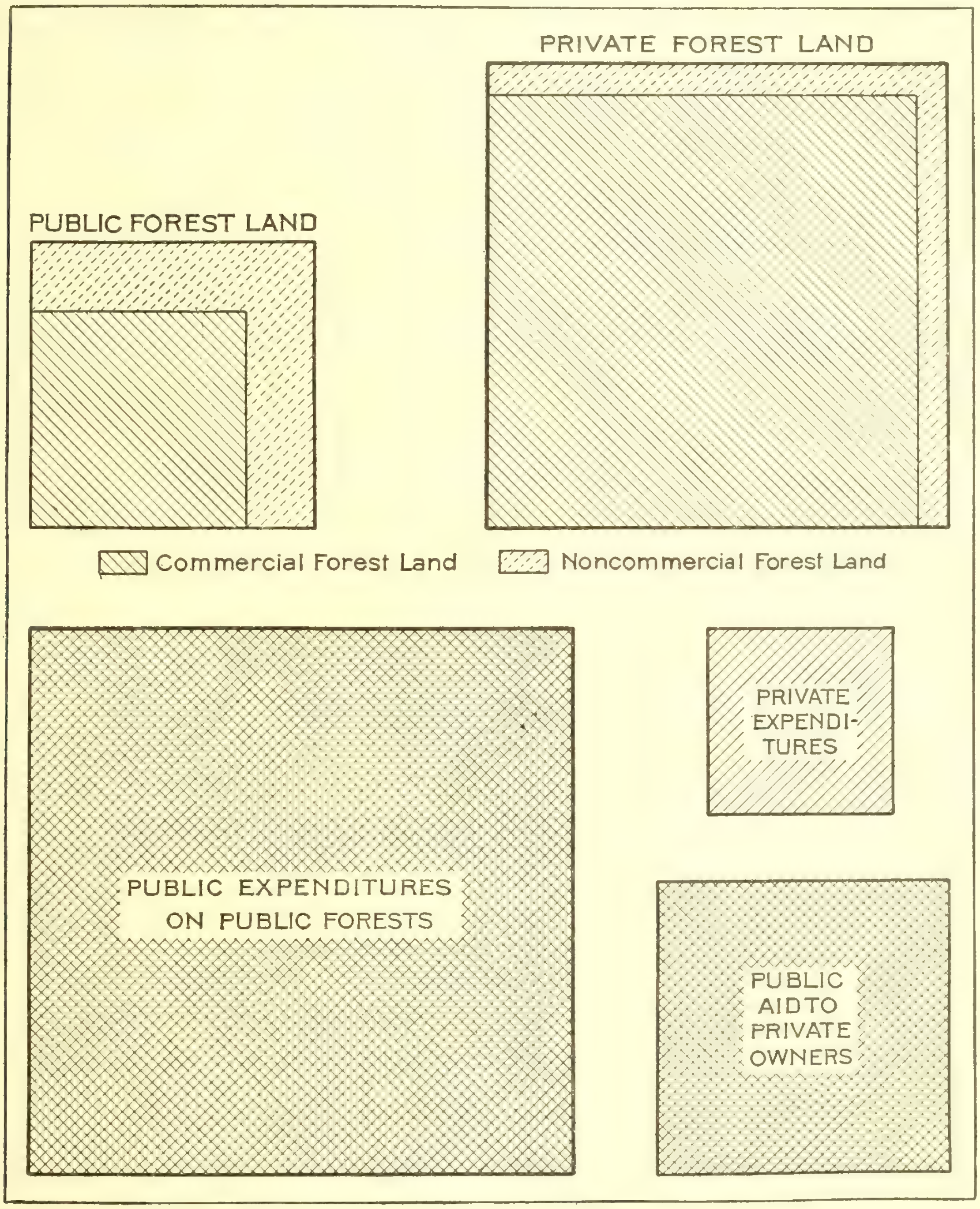

FIGURE 27.—The critical lack of balance in ownership and effort on public and private forest land.

Resolution 175 lays particular stress on a coordinated plan for meeting the entire forestry problem. That recommended is the best that can now be formulated dealing with the following major considerations:

1. The distribution of forest land between private and public ownership, and in the latter class between State and Federal ownership. The plan proposed is in broad terms and affords the opportunity to work out the detailed adjustments between private and public ownership and between the different classes of public ownership which are best adapted to local conditions and requirements.
2. Public aid that stays within the public interest, that is equitable between the Federal and State Governments, and yet offers the greatest feasible assistance to private owners. Here also great opportunity is left for flexibility in application to meet local needs.
3. Public regulation that would cover generally accepted requirements, attempt nothing impossible, be available as a quid pro quo in the public interest for concessions to private owners, and finally, be available as a reserve measure in case of future public necessity.
4. Federal assumption of only that part of the undertaking which other agencies cannot or will not carry, but where necessary assumption to the full extent of the national interest.

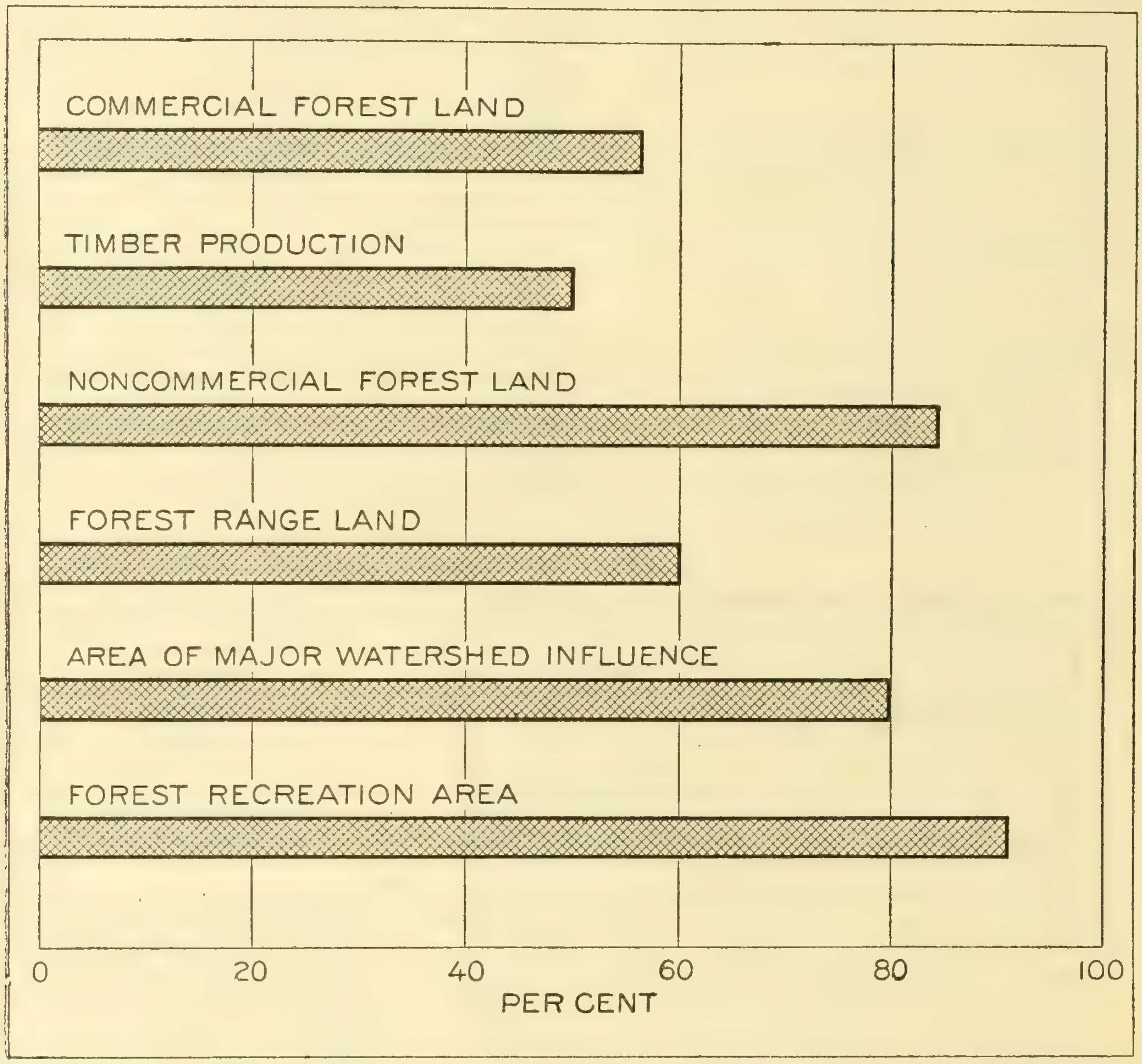

FIGURE 28.—The proportional public share in different phases of the forestry enterprise under a coordinated national plan—growing out of direct ownership of forest land.

The main obstacle to immediate action toward the consummation of this plan is the financial stringency of governments resulting from the depression. Undoubtedly the long-continued series of mistakes in forest-land policies and management has been one of a large group of economic and social maladjustments which have been at least a contributing cause of the depression.

Relief must be provided anyway. It will be far better if the relief can strike at fundamental causes and attempt the solution of national problems than if it is confined to purely transient measures. Since idle men can hardly be left to starve, it will be far better to put them to work on constructive public works. Should it prove desirable from the standpoint of relief the program can be carried out more rapidly than indicated.

Any attempt at national planning must provide for the recognition of changing conditions. One of the essentials in forest land use is, therefore, periodic revision of national plans such as here recommended, perhaps as often as every decade. This will afford the opportunity to consider not only the then existing conditions, but also to take fully into account the more and more authoritative factual data which it has been possible to accumulate, and the more and more conclusive results shown by practical trials on a large scale of different systems for meeting national objectives.

INTRODUCTION

This report is submitted in pursuance of Senate Resolution 175, Seventy-second Congress, first session, introduced by Senator Royal S. Copeland and agreed to by the Senate March 10, 1932. This resolution is as follows:

> Whereas the consumption of the forests of the United States has progressed to a point at which their early exhaustion is threatened; it being estimated (1) that over 50 per centum of all the softwood lumber cut in the United States has been cut during the last thirty years; (2) that, with a population almost 60 per centum greater today than at the beginning of the twentieth century, the United States has been using nearly three hundred billion feet of softwood lumber alone during each decade since 1900; (3) that in 1928, with a population of more than one hundred and twenty million, the annual cut of softwood lumber alone was twenty-eight billion feet; and (4) that there now remain in the territory east of the prairies, only about twenty-five billion feet of original timber; and
>
> Whereas there are great areas in the United States, which, aside from their underlying minerals, are suitable for forestation only; it being estimated that of the great land area constituting the thirteen Northeastern States, from Maine to and including the two Virginias, about one half, or seventy-five million acres, are suitable for forestation only; and
>
> Whereas proper utilization of such lands as a public domain under proper control, would to some extent effect a modification of the climate, substantially effect or control the run-off of water, supply a cheap and dependable supply of lumber, and, through development, with roads, camping places, leased hunting and fishing rights, and other opportunities for social activities, would afford valuable resources for entertainment and improvement in national health, besides giving wealth-producing and steady employment to a large number of persons; and
>
> Whereas it is desirable (1) that a coordinated plan be immediately developed for the cooperation of the Federal and State Governments in the utilization of such lands suitable for forestation only; (2) that information necessary as a basis of legislation be compiled; and (3) that recommendations for legislation be made: Therefore be it
>
> *Resolved,* That the Secretary of Agriculture is requested (1) to advise the Senate as soon as practicable whether, in his opinion, the Government should undertake to aid the States in the utilization for forestation purposes of those areas of land in the United States suitable for forestation only, and (2) to state fully his reasons for any opinion which he may submit, together with the facts upon which such opinion is based.

The resolution stresses—

1. The threat of early exhaustion of our timber supplies, particularly of softwoods in the East.
2. The existence of large areas of land suitable only for the growing of timber.
3. The fundamental and far-reaching benefits, economic and social, which would be afforded by the wise utilization of such lands under public control.
4. The desirability of developing immediately a coordinated Federal and State program for the utilization of these lands, and asks
5. That the Secretary of Agriculture advise the Senate whether the Federal Government should aid the States in such a program, and as to the facts and reasons upon which the conclusion is based.

This report, dealing as it does with one of the most important and far-reaching forms of land use, comes at a peculiarly opportune time.

The economic upheaval of the past three years has focused attention upon critical and perplexing problems of a social-economic nature that have arisen, or have come to a head during the postwar period. Public opinion is more receptive than ever before to the inauguration of carefully planned land utilization, both nationally and regionally.

Many of our most pressing problems are not of recent origin, but rather are the result of long-continued maladjustments of a fundamental nature. The Nation has grown, and grown rapidly. Practically unhampered private initiative has characterized all fields of endeavor. The genius of our people in developing and exploiting our unparalleled natural resources has made us the wealthiest of nations. But the very nature of this energetic application of effort, and its cumulative wastage of resources, has led inevitably to a current situation in which the serious lack of proper coordination between important economic and social factors seriously threatens our future prosperity.

All major plans and efforts for restoring and maintaining a state of prosperity free from periodic disruption should recognize the necessity for an adjustment of industrial practices to the requirements of social welfare and the correlation of both with the basic sources of the Nation's wealth. Agriculture, lumbering, and mining have been the primary industries based directly upon the products of the land, and have furnished the Nation's main sources of wealth and opportunity. Generally speaking, the Nation has, however, pursued a policy of unlimited, undirected, and often wasteful land use. It is evident that this time-honored policy has been too long continued, and that a definite policy involving carefully planned land utilization is necessary.

This report, while confined to the field of land use for forest purposes, has been prepared with the conviction that full and wise use of our land resource as a whole is essential to the Nation's future welfare, and with the recognition that forest use affects and must ultimately be harmonized with, the plans for agricultural and other major uses of land.

An ample and economically available supply of timber products for the needs of our people has always been, and should remain, a major purpose of forest-land use. But the problem reaches much further than that. Forest use evidently offers the only practical means of utilizing vast areas which by and large are adapted to no other major economic use. Forestry as a means of economic land use has been emphasized during the last decade by such developments as:

1. The growing accumulation of cut-over forest land stripped of its immediate timber value, evidently not needed for agriculture, but left to a precarious future with small hope of making its due contribution to the Nation's income.

2. The breakdown of private ownership of both agricultural and forest land. The fact that much land once cultivated is proving to be submarginal for agriculture promises to make available for forestry a much larger area than has previously been seriously considered or planned for. The withdrawal of private ownership is creating problems of involuntary public ownership and management of forest lands.

3. The growing appreciation of the far-reaching importance of forests for watershed protection, recreation, wild life, and forage; and

of the important part that the growing and harvesting of forests and the distributing and marketing of forest products plays in the economy of many communities and regions.

To carry out the mandate of the resolution it is necessary to outline a program coordinating the efforts of Federal, State, and private agencies in attacking the problems of forest-land use. Such a union of strength, while not a new departure in American affairs, has not as yet been satisfactorily accomplished in this field, but is none the less necessary.

The formulation of a national policy and program involves many complications. It is possible to formulate the policy and program and to present the facts upon which they are based, only by means of a careful review of various controlling aspects of the forest situation. This report, therefore, analyzes the situation as to forest land and timber supplies with respect to such things as character, ownership, availability, and present and potential timber-producing capacity; and it associates these aspects with the drain that is taking place on our forests, and with present and potential needs for timber products. It appraises the use of forest land not only for growing timber, but also with respect to the importance and the requirements of watershed protection control, recreation, wild-life production, and forage. These are treated as multiple uses, several or all of which usually apply in varying degree to the same tract. The status and progress of forestry under private and under various forms of public ownership are reviewed, the status and results of Federal and State aid are considered, and existing programs and policies are weighed. The already extensive experience of the Federal and some State Governments in managing forest lands is highly significant in pointing a way to work out the problem.

Upon this essential factual foundation the report sets up a group of coordinated national programs, each designed to accomplish the needed results in the particular field dealt with. The recommended division of responsibility by agencies, public and private, is set forth. The report proposes an immediate program for Federal and State legislation, appropriations, and other action. In this coordinated program public acquisition and management occupy a central position interrelated with all other phases.

In brief, the report is a searching reexamination and restatement of our Nation's forest problem; an analysis of the actual and potential values of forest land and its uses in relation to our national, social, and economic structure; and a constructive program for necessary action featuring Federal and State cooperation and forest land acquisition and administration.

The report has given less detailed consideration to the more immediate, and in some respects transitory, problems of the lumber and other forest products industries, which have to do with excess industrial capacity, heavy carrying charges, the merger of private ownerships, interstate compacts, etc. Not only has time not been available for thorough study and matured conclusions on such essentially industrial problems, but important though these are, their treatment is not vital to the purposes of the resolution, and of this report. These subjects, moreover, were included in the program of President Hoover's Timber Conservation Board. Nor has time permitted study of the important and involved relations of transportation and distribution costs and methods to the question immediately concerned, nor of tariffs and international economic relations in general.

Improved forest taxation has generally been recognized as an essential feature of any comprehensive forestry program, and it bears directly upon the feasibility of private forestry and upon the coordination of public and private forest land ownership. This problem, which in turn is intimately associated with the whole problem of local taxation and governmental organization and administration, is the subject of a thorough investigation by a special staff, known as the "Forest taxation inquiry of the Forest Service." A comprehensive report by that staff is practically completed and will shortly be available. This obviates the necessity for dealing with the matter in the present report.

The problem of adequate professional forestry training to supply men competent to work out the solution of the forest problems, and to practice forestry under American conditions has for some years been recognized as meriting special consideration. It has not been so much a question of quantity of professional training, as of focusing such training upon, and coordinating it with, the needs peculiar to this country. A recent publication entitled "Forest Education" by Henry S. Graves and Cedric H. Guise, made possible by a grant from the Carnegie Corporation, and conducted under the auspices of the Society of American Foresters, covers this subject, which, therefore, is not dealt with further in this report.

The data incorporated in the factual sections of this report and which underlie the recommendations herein set forth, are based, to the extent they are available, upon the findings of scientific studies and investigations. Other data, and this applies particularly to those dealing with forest land, forest volumes, growth, requirements, etc., represent the best information available from whatever source, checked by the judgment of well-informed men in the various regions. They do not, in most instances, involve detailed accuracy. The fact is that in the matter of data on these specific aspects of present and potential forest supplies and requirements, there is the greatest need for a thorough-going inventory and analysis as a basis for the development of plans by private owners, and of policies and programs by public owners regionally and nationally.

In supplying and presenting factual information, and in formulating programs and recommendations, many agencies and individuals have participated. These include, beside the Forest Service, such bureaus in the Department of Agriculture and in other Departments as the Bureaus of Agricultural Economics, Entomology, Plant Industry, the Biological Survey, the Bureau of Fisheries, the Office of Indian Affairs, and the National Park Service; also State foresters, and other State officials, as well as private individuals and agencies.

This report deals with conditions that are changing, with trends that have altered and are still changing. By the nature of its contents the detailed facts are, in many respects, transitory. Even though many of the data are approximations, they have been used carefully, and with a liberal margin of conservatism in the conclusions. The broad outlines of the picture of the forest situation are too clear to be obscured by inaccuracies in the data. The programs recommended are presented with confidence that they are justified, and in fact vital, from the standpoint of public welfare.

IS FORESTRY JUSTIFIED?

By W. N. Sparhawk, Senior Forest Economist, and
S. B. Show, Regional Forester

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CURRENT DOUBTS EXIST

Many persons are viewing the forest situation in the United States with varying degrees of doubt and questioning. The total of the very considerable effort in forestry has nowhere fully solved the forest problem. Previously developed means of action and the operation of natural economic forces have not had the full beneficial effect that was anticipated. Disappointment because no ready panacea has yet been discovered, and a realization of the difficulties of the forestry job, naturally lead to questioning as to whether the job can be done, or is worth doing.

Whether wood will continue to be a basic material need; whether there is danger of producing too much of it; whether it is worth while to keep any part or all of the Nation's forest land productive; whether private owners generally can afford to retain and manage their forest lands; whether the public should help them to do this, or should rely mainly on public forestry; whether the public treasuries can find the money needed to help private owners and expand public forestry; these and many other questions are acutely in the public mind. These doubts and questionings are facts in the situation, and must be faced.

PROBLEMS OF PRIVATE FORESTRY

Private owners of forest land have been and still are faced with mounting costs of land ownership brought about by increasing local taxation. Fire, insects, and disease continue to take or threaten to take a heavy toll of timber values. The per capita consumption of wood, and particularly of lumber, has declined and other products have cut greatly into former demands for wood. Under the existing system of unrestrained, competitive liquidation of forest values, the returns in many instances are less than the amount that was invested. It is perhaps natural, therefore, that the forest owner should view the future with grave doubts, and question whether forestry is for him.

These and other problems of private forestry and private forest lands existed before the beginning of the current depression. The depression has intensified them and forced them into the picture more prominently than ever before.

PROBLEMS OF PUBLIC FORESTRY

Public forestry also has its discouraging problems. The need for greatly enlarged public forests, in order to protect public values and to care for lands from which private ownership is withdrawing, has in but a few places been recognized and provided for as a systematically financed public enterprise. The costs of protecting the existing public forests against fire and other damaging agents, of developing these properties with roads and trails, and of improving the forest stands by planting and cultural work, are higher than was at first estimated. Many public appropriating bodies have been unwilling or unable to finance the job. At a time when all forms of public expenditures are subjected to critical reexamination and scrutiny, the forestry task of the Nation, requiring not less but much greater expenditure of public money, may well appall by its sheer magnitude. A natural defense against the number, size, and cost of the currently suggested solutions is to question whether it is worth while to rehabilitate and manage the forests of the United States.

There are several schools of thought as to what should be done. The very diversity of the proposed public measures is in itself a source of confusion. The demand for a great increase in public forests is apparently in conflict with the theory that forest lands should remain in private ownership so that they may be taxed. In some States, insistence that public ownership of forest lands must lie in the State prevents Federal ownership and management, regardless of the need and regardless of the progress the State is able to make.

The need for either State or Federal ownership is questioned by those who believe that the problem can be solved through appropriate public assistance to private owners, or, on the other hand, through public regulation of private owners. Quite readily, diversity of proposed solutions means no actual solution. Yet it is safe to assert that if one simple formula would solve the multitude of forest problems they would already have been solved.

CURRENT DIFFICULTIES ARE RESULT OF OUR FOREST HISTORY

The difficulties of today are in part the result of the entire history of public land laws and their administration, and of careless and unplanned practices of forest-land use. All the growing momentum of a long-continued and unplanned distribution and liquidation of American forest lands has culminated under the sudden pressure of economic distress, to produce the discouraging situation which the forest landowner and the public are now facing.

To attempt solution of the very real and pressing forest problems by assessing an exact measure of blame on some particular agency or group, or by arguing moral responsibility for improvement of the situation, seems futile. It is well to recognize clearly the steps which have led up to the problem that exists, so that past errors, now recognized, may not be perpetuated.

It is important to recognize, too, that a situation resulting from a long and complex history, and one affecting adversely local communities, local business, regions, State governments, and the Nation as a whole, besides the landowner himself, is not likely to be readily cured by a mere alleviation of the landowners' difficulties. It is not so easy as that.

REEXAMINATION OF NEED FOR FORESTRY IS ESSENTIAL

In pointing out the difficult and discouraging features of the current situation, there is no intent to belittle the real progress that has been made in private, State, and national forestry. A great deal has been accomplished. But that the solution has not kept up with the growth of the forest problem is evident from the very fact that so many agencies and individuals, public and private, are discussing the need for additional action. If American forest affairs were generally in healthy and satisfactory shape, there would be little discussion of them.

The difficulties and complexities of the task, and the conflicts between the evident needs of the situation and the present financial ability of the several agencies concerned, are not mentioned for the purpose of adding to the discouragement and pessimism with which various phases of the problem are viewed by different groups. These things are simply a real part of the situation. Still less is there ground for a facile optimism, which would dispose of the difficulties and needs by ignoring them.

Nothing less than a realistic recognition and reexamination of all the facts can serve a useful purpose. In the reexamination, neither pessimism nor optimism has a place. It may be found that not all the forest land is needed, and that forestry is not justified everywhere. But it does not follow from this that the area now handled under forestry practices is all that is required, or all on which the expenditures for forestry will be justified in the long run.

Were it not for the questions regarding the worthwhileness of the whole forest-conservation movement, then it would be appropriate to examine at once the present status of forestry, and to consider what additional programs may be needed. But the questions and the problems do exist. Clearly they require public understanding and public action for their solution. Whether the action takes the form of public assistance to private owners, public regulation of private owners, or public ownership in lieu of private owners, or all of these steps, is not the first question. It is rather, Is forestry justified? or, alternately, Does the Nation need forestry on the bulk or all of the forest lands? or Can the Nation afford not to have forestry generally applied?

These are not abstract questions to be debated on theoretical grounds. They are simply another way of asking, What is to be done with the 600 million or more acres of forest land of the Nation (one third of its total area) unless it is used for forestry? Has it any other profitable use? Can the Nation tolerate idleness of any considerable portion of this huge area? Which is better, productive land or idle land?

The Forest Service has no wish to base its recommendations regarding future action on beliefs that are of questionable validity.

Unless these beliefs are founded on facts, then additional programs and expenditures can hardly be justified.

WHAT IS FORESTRY

Popular discussion of the forest situation and related matters has revealed a great deal of confusion as to just what the term "forestry" means. It is, therefore, necessary here to explain what forestry has come to be in the United States.

PREVENTION OF DEVASTATION IS PART OF FORESTRY

Popularly it has been assumed that protection of forests against fire and other destructive agencies is forestry. It always will be essential to prevent deterioration and devastation of forests, if forests are to be grown. Neither forest land nor a factory can function without effective protection, but in both instances the protection merely makes it possible to produce useful goods. Prevention of devastation is merely an essential step to leave the way open for forestry; it is not in itself forestry.

REFORESTATION IS PART OF FORESTRY

Tree planting is often thought of as forestry. On many millions of idle acres it is, to be sure, the immediate need if the land is to be used. In improving badly deteriorated forest, planting also has a place. The factory must be built or repaired before it can produce goods. But planting is not the whole of forestry, any more than fire control is. On the major portion of our forest area it will not be necessary because the land is already covered with trees which with proper treatment will reproduce themselves.

SELECTIVE LOGGING IS PART OF FORESTRY

Similarly, selective logging has sometimes been held as synonymous with forestry. More specifically, it has been asserted that the cutting of only those trees which will yield the largest immediate profit is the best forestry. Forestry frequently uses selective logging as an essential tool. In many instances that form of selective logging which is best for the forest will also be most profitable for the operator. However, the production of timber is only one of the objectives of forestry. Even for timber production, the most profitable outcome in the long run may require some sacrifice of immediate profits.

MANAGEMENT FOR WOOD PRODUCTION IS PART OF FORESTRY

The volume and value of the wood crop depend on whether there is a full or partial stand, whether more or less valuable species are grown, and how carefully the stand is protected and tended. It has sometimes been supposed that nothing less than intensive care of growing forests should be called forestry. This is an extreme view. Within the limits imposed by economic consideration in the broadest sense, intensive management is an important part of forestry and is characteristic of the best forestry. On much forest land, however, production of wood crops is a relatively minor objective. On some land the necessity of safeguarding other values may even make it contrary to the public interest to utilize the timber crop.

MANAGEMENT FOR SUSTAINED YIELD IS PART OF FORESTRY

"Keeping the forest green" will not keep alive the communities that are dependent on forest exploitation unless the timber is cut on a sustained yield basis. The process of logging more rapidly than the forest can be regrown inevitably results in a period of waiting until a second crop is ready for cutting. If the lands are promptly restocked with young trees this period will be shorter than if they are not, but in either case industry will stop too long for the interlocked and interdependent businesses and social institutions, which were built on the basis of a boom in forest exploitation, to continue. The orderly utilization of forests, in accordance with the principle of sustained yield, is one of the major purposes of American forestry.

MAINTENANCE OF MARKETS IS ESSENTIAL FOR FORESTRY

Stability of forest land use and of forest industries and communities requires that there be markets for forest products. From the standpoint of the private owner, forestry will be impossible unless the products can be sold at a profit. From the standpoint of the public as a forest owner, it is also desirable that forestry be self-supporting so far as may be practicable and consistent with the other objectives of management. From the standpoint of society, regardless of who owns the forests, the existence of permanent industries using timber and other products of forests, giving employment to large numbers of individuals, and contributing toward the support of Government and of local institutions, is greatly to be desired. Development through research of ways to use forest products so that they will satisfy the largest possible number of wants and the promotion of their widespread use, must occupy an important place in a program of American forestry.

FORESTRY INVOLVES MULTIPLE-PURPOSE MANAGEMENT

THE MULTIPLE VALUES OF FORESTS

Most forest lands possess inherently more than a single value. They produce wood and numerous byproducts (resin, tanbark, mast) for domestic and industrial use. In many instances, they also produce forage for domestic livestock. They furnish food and shelter for game animals, fur bearers, and other wild life. They protect the soil against erosion. They moderate extremes of run-off and afford protection against drying or otherwise harmful winds. They beautify the landscape and offer opportunities for healthful and inexpensive recreation to millions of our people. The best forestry takes account of all these values.

MULTIPLE-PURPOSE MANAGEMENT OF PUBLIC FORESTS

Multiple-purpose management for the production, conservation, and utilization of timber, forage, water, wild life, and recreational values was first developed and is now found generally on the national forests.

Its object is the greatest total output of products, uses, and services. The multiple-purpose formula is exceedingly flexible, permitting changes in emphasis and type of use as conditions change and as public necessity requires. It regards all products and services of wild lands as having a potential place in the management picture. Its basis is that the soil productiveness is to be maintained, that the dominant and subordinate uses are dictated by the character of the land, the demands for different products and the needs of dependent communities, and that the condition of land is not static but constantly changing.

SINGLE-PURPOSE MANAGEMENT OF PUBLIC FORESTS

Another formula for the administration of public forest lands demands exclusive attention to a single objective. This concept is exemplified by the national parks, power withdrawals, and municipal watersheds. Reservations of public lands under the single-purpose formula are generally so rigid as to prevent periodic adaptation in management as public needs develop. If the public purpose in reserving and managing wild lands is to preserve, protect, and utilize all of the natural resources that go with the land, then clearly the multiple-purpose formula is best adapted to the vast majority of wild lands. The exclusive-reservation formula has a definite place in public-land management but applies only to areas of outstanding importance or quality where one use has overwhelming dominance. The multiple-purpose formula leaves room for exclusive reservation on limited areas where actually needed.

MULTIPLE-PURPOSE MANAGEMENT OF PRIVATE FORESTS

The individual owning wild land usually has only one or, at the most, a few objectives. If he is a lumberman he seeks to obtain a profit in the harvesting of timber and manufacture of lumber. Other values, such as watershed protection, game management, and scenic attractiveness have little or no realizable cash value to him and attention to them may require costly alterations in his logging practices. If conflicts exist, the secondary values must be sacrificed. If no conflict exists, private management may by chance preserve all public values.

A major aim of public policy is to bring about multiple-purpose management of the private forest lands on which several values exist. The difficulties confronting the individual owner of such forest land, where he cannot reimburse himself for attention to the public values, but where the public is insistent that they be conserved, require definite recognition and attention.

FORESTRY IS A COMPREHENSIVE AND COORDINATED TECHNIQUE OF LAND MANAGEMENT

In summary, then, American forestry involves protection of existing forests, restoration of denuded lands by planting, perpetuation of forests by appropriate logging methods, and use of the sustained yield principle. It involves whatever efforts may be required to sustain markets for forest products. A definite aim is also to manage forest lands for values other than timber. Forestry is a coordinated technique, with many purposes and methods. These purposes cannot be attained through accident or through unplanned action. Only conscious, deliberate, and planned forestry can get the highest values from forest lands. Forestry is land and resource management in the widest sense.

THE DIRECT VALUES OF FORESTS

FORESTS AS A SOURCE OF WOOD

WOOD FOR HOME CONSUMPTION

As a source of essential raw materials forests have played a vital part in our national history. An abundant and cheap supply of forest products was available in the initial settlement of the country, and American civilization early became characterized by a very high rate of wood consumption. The per capita use of wood and the total volume used annually have declined in the past 25 years, but the United States still uses more wood per capita than many other nations.

A decline in per capita consumption was to be expected, once the rapid expansion of the pioneer period was past. That this expectation has been realized does not mean that an abundant supply of forest products is no longer necessary. In spite of all the substitution of other materials for wood, it remains an important construction material, dominates the box and container market, and is irreplaceable in meeting the increasing use of newsprint and heavy wrapping paper. No satisfactory substitute has been found for many other uses of wood. The forms in which wood is used have changed rapidly, and they are still changing. But careful studies of the future requirements for wood, as discussed elsewhere in this report, indicate its permanently important position among our physical needs.

The decline in consumption of wood has been due in part to the comparative inertia of the producers and manufacturers of wood products. Unlike producers of many other materials, including some which are used extensively in place of wood, they have failed to compete aggressively in adapting wood to consumers' needs and preferences, in developing new uses, and in popularizing wood as a raw material. While producers of competing materials have been spending millions in scientific and technical research for the purpose of improving their products and finding new ways to use them, wood producers, with the exception of pulp and paper manufacturers, have spent relatively little.

Nevertheless, even though other materials might conceivably be substituted for wood in virtually all of its important uses, it would be contrary to the public interest for this to happen. From the public standpoint there are many advantages in having a variety of materials capable of meeting our needs. It is particularly desirable that wood be available in abundance and be employed liberally, not only because of its great intrinsic merits, but also because of its relative cheapness. Unlike most of the competing materials, it is renewable, and it can be grown in most parts of the country fairly near the consumers. It is, consequently, less susceptible of monopolistic or quasi-monopolistic control. The continued utilization of wood on a large scale is in the public interest because it makes possible the productive use of land which otherwise would produce little or nothing, and thus contributes to the economic welfare of large numbers of people, of many communities, and of the country as a whole.

Provided efforts comparable to those in behalf of many other materials are exerted to make wood serviceable and to educate consumers in its use, the demand for wood may even increase. Such efforts will be futile, however, unless provision is also made for meeting the demand with continuous dependable supplies at reasonable cost. We have sufficient forest land to meet an increased demand, providing it were all well stocked with growing timber and carefully managed. The stock of growing timber, however, is already so depleted that no amount of careful management within the next 60 or 80 years will enable even the present output to be maintained, let alone increased. Moreover, the process of depletion is still going on.

It is clearly the soundest public policy to fill the manifold needs for wood, as far as possible, with our own native products. Economic self-sufficiency, in this sense, has characterized the Nation's history. Except for relatively small quantities of special tropical woods and forest products, we have been able to supply our own requirements in peace and war. Wood is employed for thousands of specific uses, for many of which particular kinds or grades are essential, and for many more of which substitution of other materials is impracticable. Particularly in time of war an undue dependence on other nations for wood products would place us at a serious disadvantage.

Heretofore the great variety of our native woods, and their technical adaptability to most of our wood needs, have not only been a great economic asset, but have accustomed us to assuming a continuation of supplies. Already, however, many special kinds and grades are becoming scarce and costly. Requirements for many of these can be met by importation, but at added cost, and by losing the advantages of manufacture within our own borders.

WOOD FOR EXPORT

Many of our native woods possess technical qualities and uses which fit them for export to other countries. One of the principal reasons why this country has enjoyed a favorable position in international trade has been the wide variety of its products. The greater the number of different products, the more numerous are the opportunities for profitable trade, and the smaller is the dependence on a single article. In agriculture, manufacturing, or commerce, the single product farmer, factory, or nation is quickly and often adversely affected by fluctuations in demand for the single product.

With diversified products, there is less likelihood that all will be out of demand at a given moment. The manifold kinds of wood and wooden articles that are suitable for export are thus an important balancing factor in helping to maintain the foreign business of the Nation. It is, therefore, worth while to maintain and perpetuate the native woods, wholly aside from the desirability of economic self-sufficiency.

FORESTS AND CONSERVATION OF WATER AND SOIL

During the pioneer period forests were valued mainly as a source of wood. As long as the mountain sides and the river bluffs and the headwaters of the rivers were clothed with dense forests, the beneficial effects of forest cover in regulating stream flow and preventing soil erosion did not become strikingly evident.

But toward the end of the last century, as wholesale and heedless deforestation spread over more and more of the headwaters of streams used for navigation and for irrigation and domestic water, the accumulating evidence of direct observation forced recognition of the importance of forests in protecting many watersheds. The act of Congress of 1897 which made "maintaining favorable conditions of water flow" one of the two purposes of the administration of national forests did not, of course, undertake to establish by legislative enactment a scientific law of universal applicability. It did take into cognizance a relationship between forest cover, erosion and run-off, proven in numerous instances both at home and abroad. It recognized that America is not immune to the disasters which have followed deforestation of watersheds in other countries. The act of 1911 which made protection of headwaters of navigable streams the basis for purchase of national forest areas in the eastern United States, gave further formal recognition of the watershed protection value of forests.

Specific data bearing on this function of forest cover are given elsewhere in this report. Research and observation by trained men show that in many of the forest regions deforestation starts processes of flashy run-off and erosion which affect adversely water supplies and navigation. In late years impressive evidence has accumulated showing the prevalence of erosion on once forested hill and bluff lands which have been heavily grazed or used for agriculture. Destruction of the fertility and usability of the lands through sheet and gully erosion has already removed many millions of acres from agricultural use, and is in fact one of the chief reasons for the widespread abandonment of this class of land. Dumping of sand and silt into the streams has created problems of diking, overflow, and destruction of navigability far from the source of the eroded material.

Maintenance of forest cover to protect watersheds is not necessary on every part of every watershed. But estimates given elsewhere in this report show that there is a very large area of land which must be kept under forest or restored to forests if the watersheds of the country are to be kept in good condition. Lands producing commercial timber are not the only source of concern. In the West, particularly, large areas covered with inferior tree growth or brush have high value for protection of water and soil. Like the commercial forest lands, their protective value is quickly impaired by fire and overgrazing.

FORESTS AS A SOURCE OF RECREATION

The pioneer had little interest in the forest as an environment for recreation. Variously he hunted in it, used it as a source of wood, or struggled to annihilate it. As part of his normal environment, he necessarily accepted it. And his opportunities for recreation were few.

Later, as urbanization proceeded and wealth and leisure increased, more and more people acquired the means and the desire to leave their normal environment of the city, for at least part of each year. Along with journeys to foreign lands and to the seashore, the forests in many parts of the country acquired a recognized value for outdoor recreation of a primitive and simple sort. The Maine woods, the White Mountains, the Adirondacks, the Colorado Rockies, and the Sierra Nevadas became noted for their recreational values and attractiveness.

Until the large-scale production of low-priced automobiles and the accompanying increase in good roads reached full swing during the past 15 to 20 years, recreation in forest areas was beyond the attainment of millions of people. But this situation has now changed radically. Even the less spectacular and beautiful forest areas are heavily used by the rising tide of recreationists. Outdoor recreation in the forests has become an established part of the American standard of living. It is highly desirable as an aid to social, economic, and individual health, and fullness of life. It will certainly continue on at least the present scale.

Many of the most spectacular and heavily used forest recreation areas have been set aside under public ownership for the exclusive purpose of recreation. The national parks, State parks, and county and municipal parks in many States, have sought to furnish the answer to the mounting demand. But in terms of actual present day use, it is doubtful if these special recreational reservations take care of as many people as do the vast areas outside of parks—ordinary forest country, which possesses no outstanding scenic or inspirational features.

This phenomenon of widespread use of the ordinary run of forested country arises from several basic facts. One of the most important of these is that for the vast majority of people the enjoyment of forest recreation depends on availability within a relatively short distance, and on cheapness. The individual with ample means and leisure may, depending on his taste, climb in the High Sierra or the Canadian Rockies, hunt the moose in Maine or the bighorn in Idaho, fish for salmon in Alaska or the steelhead in the Klamath, or enjoy the scenic and inspirational values of the national parks. He is able to pick and choose and to enjoy the highest quality of the outdoor sport of his preference.

Most people, on the contrary, having both limited time and money, must take what is close or nothing. If forest country is within 100 miles of home, it will be used, even though the highest mountain is only a low hill, the largest game a rabbit or a squirrel, the biggest fish a fingerling trout, and the finest view one that could be duplicated in any wooded region. The most heavily used recreation areas are those closest and most readily accessible to the largest number of people.

Another reason for the heavy use of nonpark areas is the variety of outdoor recreation which they offer in contrast to park areas, which are limited by their very nature and purpose to a few forms. It is a cardinal principle of park management that all forms of hunting are prohibited. This is necessarily so because the purpose of parks is to preserve and protect. But many people pick hunting as the highest form of personal enjoyment in outdoor recreation. The outstanding features of parks tend to be concentrated, and the people visiting them are necessarily concentrated also. Crowding is inevitable, camping loses the quality of freedom and isolation, policing of the crowds cannot be avoided, and restrictions are numerous. The greater freedom and lack of supervision which are possible when crowds can spread out in the large areas of ordinary forest country appeal to many people in a very fundamental way.

Thus very large areas of American forest lands have acquired a high recreational use and value, simply because they are readily accessible and are forest lands. It has become increasingly evident that recreational uses of many kinds can go on alongside of other uses of forest lands, such as conservative lumbering and grazing. Recreational uses such as hunting, fishing, camping, and climbing do not require the exclusive devotion of the land to a single purpose. As on the national forests, recreation on most lands can be simply one of the products of multiple-purpose management.

The use of forests as recreation grounds seems certain to be greatly stimulated by the increasing leisure which will result from the general trend toward a shorter working week. Because nearness and ready availability to centers of population are essential if the socially desirable outdoor recreation habit is to continue, the widest possible distribution of forest areas is clearly in the national interest. The trend of recreational development is strongly in the direction of providing the simpler and less expensive forms of recreation, such as picnicking, camping, fishing, and hunting. When recreation is handled as a byproduct of forest production or watershed protection, the cost to the public is naturally less than if furnished in a public park. Later sections of this report will discuss in detail the forest areas needed for recreation.

FORESTS AND WILD LIFE

The forest is the natural habitat of many species of fur bearers and upland game, including game birds and many of the finest big-game animals. An overwhelming majority of the hunting for big-game animals and upland birds is in the forest areas. The deer is by all odds the most important big-game animal, if for no other reason than its relative abundance and wide distribution. It is typically a forest species. Even where heavily hunted, it maintains itself or increases, provided it receives any sort of reasonable protection under the game laws, and provided that its forest habitat is not destroyed. Other game species and fur bearers as well can maintain themselves only if their natural habitat of woodland is maintained.

A very large proportion of the inland fishing waters are affected by the treatment of the forest land. Erosion, following deforestation, generally results in muddy streams which afford an unfavorable habitat for most game fish. Denuded watersheds commonly give rise to intermittent flow of streams, with a tendency to reach such low levels of flow that only a portion of the normal fish population can be supported. Removal of the forest shade results in a rise in water temperature which is deleterious to trout and other important species of game fish.

Hunting and fishing, like other forms of outdoor recreation, are available to the great majority of people only if the hunting and fishing grounds are accessible within a short distance and at low cost. To serve this public end is a major function of forests.

FORESTS AS LIVESTOCK RANGES

In many parts of the West, with relatively small areas of crop land, the mainstay of agriculture is the production of meat, hides, and wool. The forest ranges carry the flocks and herds for part or most of the year, and the crop land produces hay and grain to carry them during the winter. The 83 million acres of national-forest-range land are essential in the agriculture of many western areas. The forest range is notably important also in large areas of the southern pine region, where the characteristically open growth of timber allows an undergrowth of nutritious grasses. In these and other regions the forage from forest ranges is a vital part of the agricultural economy. Without it, the opportunity for successful farming would be materially reduced.

The forage crop on many forest ranges has been depleted in quantity and deteriorated in quality through persistent overgrazing. Unrestricted and excessive grazing in many places has damaged or destroyed the small trees and seedlings and thus prevented reproduction of the forest. By destroying the protective ground cover and trampling the soil it has led to serious erosion and gullying. Under a properly regulated system of grazing these things would not have happened, for it is entirely possible with careful management to utilize the forage crop without harm to the forest values. On millions of acres of western ranges, the carrying capacity had been reduced greatly before the national forests were established and a system of range control inaugurated. Since then these ranges have been greatly improved as a result of systematic management.

If properly handled, the forests of the West and other regions can continue to furnish range for large numbers of domestic livestock, while at the same time they are producing timber, protecting watersheds, and furnishing opportunities for recreation.

FORESTS AND FOREST INDUSTRIES ARE IMPORTANT ELEMENTS IN OUR ECONOMIC STRUCTURE

Nearly one third of the country's land area, or approixmately 600 million acres, is forest land of one sort or another. This is a greater area than all of the United States east of the Mississippi River. It is half again as large as all of our crop land. In 32 States the area of forest land exceeds the combined areas of crop land and plowable pasture, and in 23 of these it is from twice to more than twenty times as great.

The value of our forests and primary forest industries has been estimated at something over 10 billion dollars. The gross value of products averaged close to 2 billion dollars a year just prior to 1929. During the last 100 years the value at the mill of sawed lumber alone has aggregated between 30 and 35 billion dollars, and the value of all products was certainly not less than 50 billions.

In 1929 the forest and woodworking industries employed directly 1,300,000 workers, or about 2½ percent of the gainfully employed persons in the United States. The building industries, which to a considerable extent depend upon forest products in one form or another, gave employment to more than 2,500,000 persons. In each of 20 States more than 30,000 workers were employed directly by the forest and woodworking industries (including pulp and paper manufacture). The number employed exceeded 50,000 in 10 of these, including such widely separated States as New York, Washington, Michigan, Illinois, and North Carolina. In Washington and Oregon 135,000 persons, or one eighth of all those gainfully employed, were engaged in this group of industries.

Imports of forest products, including paper, amounted to more than $400,000,000 in 1929, or nearly one tenth of all our imports.

This was only partially balanced by exports, valued at approximately $250,000,000.

Forest products make up about 8 percent of all the revenue freight carried by our railroads, and the supplies, equipment and other materials used by the forest industries account for a large additional tonnage. In recent years the railroads have required 80 to 90 million ties a year to keep up their tracks, and have paid around $120,000,000 a year for these and other timber.

Some $45,000,000 a year is paid for the timber used to mine our coal and other minerals, not including the large quantities used in the oil fields. It would be superfluous here to dwell at any length upon the importance of the rôle that wood and wooden products play in the construction and furnishing of our homes and farm buildings, as raw material for our newspapers, books and magazines, and in countless other articles used in our daily living.

Practically all of the streams used for municipal water supply, power or irrigation have their sources and considerable portions of their catchment basins in forest lands. Millions of our people look to the forests, or to forests and the associated rivers and lakes, for the health and enjoyment obtained from outdoor recreation. If it were not for their forest cover, many of our hills and mountain sides would become barren, rocky wastes and their soil covering would bury the farm lands in the valleys or would fill the reservoirs and irrigation ditches or clog the navigable channels below.

FORESTRY AND AGRICULTURE

The perpetuation of forests is of particularly vital concern to the agricultural industry. These two major forms of land use, once regarded as competitive, are no longer so. Instead, with the advance of forest depletion and the gradual retreat of agriculture from the poorer lands it is coming to be realized that the two uses are complementary and to a considerable degree interdependent.

AGRICULTURE IS A HEAVY CONSUMER OF FOREST PRODUCTS

Directly or indirectly, the rural population has always used the lion's share of our forest products. In the settlement of the forested regions, the timber furnished a ready-to-hand material for building and fencing and fuel which required little or no cash outlay. The phenomenally rapid settlement of our great treeless central region would have been much slower had there not been a readily available and reasonably cheap timber supply in the Lake States. In most parts of the country, farm dwellings and barns and other buildings are still built largely of wood and their continued use requires wood for repairs and upkeep. In spite of the growing use of steel and cement, the bulk of fencing still requires wooden posts. Wooden boxes, barrels and crates are used in enormous quantities for the shipment of farm products. Tool handles, farm wagons, and many sorts of farm equipment are made of wood. In common with other citizens, farmers consume wood in the form of paper, furniture and a multitude of wooden products. Millions of farmers still depend chiefly or wholly upon wood for fuel.

In 1924, not only did several million farms produce timber and fuelwood for their own use, but more than 1,200,000 farmers purchased lumber, posts, firewood, etc., at an aggregate cost of $167,000,000. The actual cash outlay for these materials was more than three fourths of the expenditure for fertilizers reported by 2,200,000 farmers. An adequate supply of a variety of forest products at low cost is vitally essential for the agricultural prosperity of most parts of the country.

AGRICULTURE IN MANY REGIONS DEPENDS ON ADEQUATE SUPPLY OF WATER

Besides their function as suppliers of raw materials, forests in many regions, particularly in the West, serve agriculture through their influence on water supplies. Without dependable supplies of water it would be impossible successfully to cultivate the 19 million acres of irrigated land. In the 11 Western States more than 240,000 farms, or almost half of the total number, depend on irrigation water. Approximately 17,500,000 acres are irrigated in these States. The total value of these irrigated farms in 1930 was $4,500,000,000 and more than $900,000,000 has been invested in the irrigation works. A large proportion of the water used in irrigation originates on forest land. Without the forest cover, the flow of water would become less regular, larger and more costly storage reservoirs would be necessary, and great expense would be entailed in removing silt from the reservoirs and ditches and, in many instances, in rebuilding dams.

FORESTS PROTECT FARMS AGAINST DAMAGE FROM EROSION

Another way in which forests serve agriculture is by holding in place the soil on slopes and along the banks of streams. Many thousands of acres of rich agricultural bottom-land, in the East as well as in the West, have been ruined by the deposition of silt, sand, gravel and boulders which were washed down from the hillsides after the forests were destroyed. Hundreds of thousands of acres have been cut to pieces by deep gullies which could have been prevented by preserving the forest cover at the critical points. The influence of forests in relation to water supplies and erosion is discussed in detail elsewhere in this report.

FORESTS FURNISH SUPPLEMENTARY INCOME TO FARMERS

Combined agriculture and forest work afford a livelihood to hundreds of thousands of farmers who would find it difficult to make a living from farming alone. This is particularly true in localities where the land suitable for cultivation constitutes a relatively small proportion of the total area or is of low productivity. These conditions are common throughout the inhabited hill and mountain regions, and also in the more level, sandy portions of the Lake States and the Southeast. The forests enable the farmers to employ themselves and their teams and other equipment profitably during the winter or other seasons when farm work is slack. They may either work in their own woods, getting out timber for home use or for sale, or they may work for wages in logging camps or mills. In 1929, forest products to the value of $240,000,000 were cut from 2,500,000 farms. From one third to one half of this sum represents cash income for materials sold. In 1919, forest products worth $394,000,000, of which $217,000,000 worth were sold, were cut from 1,800,000 farms.

In many instances forest work or the sale of forest products provides a major portion of the farm income. This has been particularly true during the early stages of settlement, while the farms were being cleared. In the northern portion of the Lake States, for example, more than 50 percent of the settlers' income during the first four years has come from sale of timber products and work off the farm; even after 20 years, more than one fourth of the total income was derived from these sources.[1] Dependence upon income from the forest or other sources than the farm itself is not confined to newly settled regions, however. It is found also in long-settled portions of the Appalachian Mountains, the Ozarks, and the Northeast. Out of 2,222 operated farms in two counties of central West Virginia in 1928, only 768 gave exclusive employment to the operators. The operators of the remaining 1,454 farms engaged in other work, much of it in the woods or forest industries, for a considerable portion of the year.[2] In the Kentucky mountains, as in similar regions where the population is relatively dense and all of the land suitable for the purpose has long been utilized for crops and pasture, the maintenance of satisfactory living standards requires a larger income than can be obtained from farming alone. The large area of forest land, if properly utilized and supplemented by local manufacture of the forest products, offers the best prospect of furnishing supplementary employment.[3]

In many European countries the forests play an exceedingly important role in the farm economy. Not only do millions of farmers own little tracts of woodland, as in France, Germany, Austria, Finland, and the Scandinavian countries, but large numbers of them find part-time employment in the public forests or those belonging to other large owners.

An excellent example of the way in which forestry and farming can be coordinated is the small holdings project that is being developed by the Forestry Commission of Great Britain. Under this scheme, the better quality land on the tracts acquired for State forests is reserved for agricultural use. This land is then divided into small holdings, averaging about 10 acres, which are equipped with buildings and leased to settlers. Each of these small holders is guaranteed 150 days of forest work a year; the rest of the time he works on his holding, raising food for his own use and for sale. In this way the Forestry Commission obtains a dependable supply of resident workers for reforestation, development and eventual utilization of the State forests. At the same time hundreds of workers and their families are settling on farms and thus gradually repopulating the countryside in the neighborhood of the forests.

FOREST INDUSTRIES AFFORD LOCAL MARKETS FOR FARM CROPS

Permanent forests also help agriculture through the markets for farm products which are afforded by the nonfarm population that is dependent upon forest work or work in wood-using industries. The logging camps and the industrial villages require large quantities of vegetables, fruits, meats, and dairy and poultry products, as well as hay and grain where horses or mules are used in logging. Local farmers can frequently sell directly to the consumers, thus avoiding most of the costs of transportation and marketing, and can thereby receive much better prices than if they had to ship their produce out to more distant markets.

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[1] Hartman, William A., and John D. Black. Economic Aspects of Land Settlement in the Cut-Over Region of the Great Lakes States. U.S. Dept. Agric. Circular 160. 86 p., illus. 1931.

[2] Peck, Millard, Bernard Frank, and Paul A. Eke. Economic Utilization of Marginal Lands in Nicholas and Webster Counties, W.Va. U.S.Dept.Agric.Tech.Bull. 303. 64 p., illus. 1932.

[3] Clayton, C. F., and W. D. Nicholls. Land Utilization in Laurel County, Ky. U.S.Dept.Agric. Tech.Bull. 289. 100 p., illus. 1932.

Forest industries create a market for more than the food products of the farms. They also enable the farmers to dispose of their woodland products much more readily and at better prices than would be possible if there were no wood-using industries in the vicinity. For instance, farmers within trucking distance of a pulp mill or a woodenware factory can usually sell timber to much better advantage than those farmers whose only nearby market is for firewood.

FORESTS HELP TO LIGHTEN THE FARM TAX BURDEN

Under the prevailing system of financing local government chiefly by the taxation of property, it is obvious that productive forests and wood-using industries help to support roads, schools and other governmental functions. It is equally obvious that when the forests are destroyed and the dependent industries close down or move away they no longer pay taxes. Unless costs can be correspondingly curtailed, which is seldom the case, their share of the public revenues must then be paid by the remaining property, or must be met by contributions from taxpayers in other parts of the State. Unless the land formerly occupied by forest can be promptly converted into farms—and this can no longer be done in any forest region of the United States—the burden on existing farm and village property is bound to increase. This has been the unpleasant experience of farmers in many cut-over land regions.

FARM ABANDONMENT FOLLOWS FOREST DESTRUCTION

In many regions where agricultural settlement was directly associated with the utilization of the forests, the exhaustion of the timber and withdrawal of the industries has worked great hardship. The lack of opportunities for supplementary work, the loss of local markets for farm produce, the dismantling of railroads following cessation of the timber traffic, and the increased burden of taxation with a narrowing of the tax base, have made it impossible for many settlers to continue. Widespread abandonment of farms and virtual depopulation have followed, even in localities where permanent agricultural utilization of part of the land would be economically justified.

FORESTRY ON SUBMARGINAL LANDS PREVENTS UNECONOMIC USE FOR AGRICULTURE

There are, of course, many millions of acres which it is possible to cultivate, but which should never be farmed. Yet, as long as cut-over land remains in private ownership, whether in farms or outside of farms, there will be an urge to use it for crops or pasture. These are the only forms of use which most landowners are able to envision. Much inferior land (from the agricultural standpoint) has been more or less temporarily added to the agricultural area for this reason. Its continued operation can only result in disappointment and eventual failure of the settlers. It also means a loss to the community at large, because of the expense of providing the necessary schools, roads, and other services.

Steps should be taken to prevent further expansion of farming on such land. Definite assignment of the land to forest growing, either through its acquisition by the public, or by private owners with the cooperation of the public, will tend to remove the incentive to put it to uneconomic agricultural use. This is a very important reason, which is generally overlooked, for the development of productive forests on the large areas of land which is submarginal for agriculture but physically capable of cultivation.

FORESTRY HELPS TO MAINTAIN POPULATION IN SUBMARGINAL REGIONS

We hear much, nowadays, about agricultural overproduction and the need for getting submarginal land out of agricultural use. It is sometimes suggested that the rural inhabitants of the more or less marginal regions should migrate to better agricultural land elsewhere or to industrial centers where they can engage in other kinds of work. This would not materially affect agricultural overproduction—probably not at all, so far as the general market is concerned. A few of the persons thus migrating might better their condition, but many of them would be even worse off than before. Whether migration were allowed to take its natural course or were stimulated, it would seldom result in complete depopulation. The process would probably be selective, leaving behind those individuals with the least initiative or economically the weakest, and thus would give rise to rural slums which might be even more difficult to deal with than those in the cities.

Instead of getting the people of such regions to seek employment elsewhere, it would be far better to bring employment to them. By establishing industries which will supplement agriculture, an even larger population than exists now can be supported on a much higher level than at present. Agriculture may be submarginal so far as the general market is concerned, but may still be supermarginal if its products can be utilized in the same locality where grown. This is particularly true in localities where farming can be conducted on a part-time basis, and where a portion of the farmers' income can be derived from other industries.

Just as in the case of nations, the people of a given region can purchase the products of other regions only if they produce commodities or services which can be sold in outside markets. As a general rule, submarginal agricultural regions cannot economically, nor should they attempt to raise farm products for the general market. The forest products of such regions, however, in many instances are eminently suitable for trade with the outside. The cost of living will generally be lower in decentralized, forest-farm communities than in the larger industrial centers, and long hauls and various intermediate costs between the forest and the factory can be eliminated. For these reasons, wood products industries in such communities can compete on a favorable footing with similar industries in the larger centers. The more completely the timber can be manufactured into finished commodities within the region of origin, so much the better will the forest resource serve to support the local population and increase its ability to buy the products of other regions.

FORESTRY AND EMPLOYMENT

EMPLOYMENT IN FOREST INDUSTRIES IS DECREASING

Forestry and the lumber industry directly employed an average of 650,000 workers in the United States in 1929. This did not include the large amount of part-time work by 2,500,000 farmers who got out wood and timber from their own land and worked it up for their own use or hauled it to market. Another 650,000 were employed in wood-working plants of various sorts and in the pulp and paper industry. The persons employed in the transportation and merchandising of lumber and other forest products are not included in the above figures.

Employment in the forest and related industries has been decreasing for more than 20 years. So far, this has been due only in small part to increased output per man. The principal reason is the decrease in total output. For instance, the number of wage earners employed in what the Bureau of Census classifies as "the principal lumber industries" decreased 23 percent between 1909 and 1929, while the output of sawed lumber decreased 17 percent. In 1899 the ratio of total lumber cut to number of wage earners in logging camps and sawmills was 85,000 board feet per man. In 1909 the ratio fell to 81,000 feet, and in 1919 to 72,000. In 1929 it rose to 88,000 feet. It is quite possible that the future will see considerable technological advance in the processes of harvesting and fabricating wood products, and that this will tend to reduce the quantity of labor per unit of output.

FORESTRY WILL HELP TO STABILIZE EMPLOYMENT

To the extent that this takes place, and to the extent that a decreased output represents a reduction in our capacity to consume timber products or to sell them abroad, a corresponding reduction in employment must be expected. However, if we can eliminate the wastes involved in the present system of forest exploitation and migratory industries, there is reason to believe that it will be possible to reduce costs and in the long run materially to increase the consumption and export of timber products. If this should come about, the forest industries might require an even larger number of workers than are employed now.

Whether or not total employment should increase, there are manifest advantages in stability of employment in the various timber regions. Permanently productive forests will not only give fairly steady work in protecting and caring for the forest and harvesting the crop, but they will also lead to the establishment in the same vicinity of wood-using industries which will also employ many workers. Although they may not contribute greatly toward relieving permanent technological unemployment in the urbanized industrial regions, they will be very helpful in taking up the slack in the immediate regions where they are located.

EMPLOYMENT OPPORTUNITIES UNDER SUSTAINED YIELD FORESTRY

IN EUROPE

For European countries, where many forests have been under sustained yield management for a long time, there is considerable information on employment in forestry and forest industries.

In Denmark, 750,000 acres of forest furnished employment in 1912 equivalent to full-time work for about 6,000 persons, or one worker to 125 acres. The actual number employed was considerably greater, because much of the work was seasonal, part-time work. Few, even of the regular forest workers, are employed in forest work for more than 200 days a year. During the remaining time most of them work on farms.

In Sweden, employment averages about 1 man to 400 acres in the south and 1 man to 1,400 acres in the less productive forests of the north.

In 1927 the State forests of Prussia gave work to 143,600 men and women. For the majority of these the forest work was supplementary to agricultural or other employment, for the men worked an average of only 98 days and the women 29 days. The total was equivalent to about 33,000 year-long employees for the 5,500,000 acres of forest, or 1 to 167 acres. By 1930 the ratio of employment was reduced to 194 acres per person. This includes logging, but not work in sawmills or other manufacturing industries. For all of Germany, with 31,000,000 acres of forest, from 1,500,000 to more than 2,000,000 persons are employed part or full time in forestry, logging and wood-using industries.

In Austria about 1 person for every 100 acres of forest is engaged in forest work and if transportation, manufacture and wood-working industries are included, 1 for every 30 acres.

For Czechoslovakia, including the industries, there is 1 worker for every 35 to 50 acres.

In Alsace-Lorraine, not including transportation and mill workers, about 25,000 persons, mostly farmers, find part-time employment in forestry and logging. This is equivalent to 1 full-time worker for 225 acres of forest.

In Switzerland, the 1,700,000 acres of public forests give work to nearly 10,000 full-time and about 30,000 part-time employees, equivalent to perhaps 1 full-time worker for 100 acres.

The figures for England are interesting because they show the increase in amount of employment as forests develop from the planting stage to full production. The Thetford Forest is almost entirely a planting project so far. When the area was taken over, about 6 gamekeepers were employed on the entire 26,500 acres. Since planting began the number of employees has averaged between 200 and 300, including both full-time and part-time workers. The Forest of Dean, which contains some mature timber but is not yet fully stocked, gives work to 381 men in forest and sawmill on less than 20,000 acres. When the forest is fully productive it is estimated that there will be work for about 700. The Tintern Forest, which has been under management for 30 years and is well stocked, gives work at the rate of 1 full-time employee to 35 acres. This includes silvicultural work, felling and extraction, and a certain amount of rough manufacture. The British Forestry Commission estimates that on the average, forests in the planting stage require 1 full-time worker for 100 acres and forests in the productive stage, 1 worker to 50 acres. Including hauling and woodworking, fully productive forests give work to 1 person for every 25 acres.[4]

The wide variation in the above figures is not surprising. Not only is there great variation in the productiveness of the forests of different regions, but the amount of work involved in timber growing and utilization also varies widely with the kind of timber that is grown, and with the kinds of products that are made from it.

IN THE UNITED STATES

There is little information in this country to indicate how many persons might be employed in developing and managing sustained yield forests and utilizing their products. The Harvard Forest of 2,100 acres in Massachusetts, which has been under management for 25 years, employs 5 men all of the time and about 10 others for seasonal work, or roughly one full-time employee for 250 acres. This includes work in the woods and sawmill. In Maine, the Bates College Forest of 11,300 acres employs 5 year-long men and about 35 others for periods of 2 to 6 months in forestry and logging, or at the rate of one full-time man to 600 acres. This figure does not include sawing or further manufacture of the lumber. The number of employees will probably increase as the output of timber increases. A wood-working industry which has been operating in the same locality in northern Vermont for more than 80 years employs about 200 persons in harvesting and manufacturing the timber from about 8,000 acres, or at the rate of one worker to 40 acres. A southern company which is practically on a sustained yield basis cuts about 12,000 board feet a day of second-growth timber. About 100 persons are employed during most of the year. This is roughly at the rate of one worker to 120 acres. The State Forester of Connecticut has estimated that 500 men could be profitably employed for 6 months every year on the 63,000 acres of State forest. This is equivalent to one year-long man for every 250 acres.

A very rough estimate of the aggregate possibilities for employment in American forests may be derived as follows: In 1929 there were employed in forestry, logging, and wood manufacture an average of 1,300,000 persons. Including the part-time work of farmers, the total was equivalent to possibly 1,500,000 full-time workers. The total cut of timber (not including small trees cut for firewood, etc.) was approximately 54 billion board feet, or 36,000 board feet for each person engaged in the industries. Our forest land, averaging poor and good sites together, can probably grow timber at the rate of 100 to 150 board feet or more per acre per annum. At the present rate of employment this would give full-time work to one man for every 240 to 360 acres. Inasmuch as the present employment includes very little silvicultural work, and since a considerable amount of work in connection with the utilization of range and recreational resources is not included in the above figure, it is possible that our forests when fully productive may give direct employment to at least one person for every 250 acres, or the equivalent of full-time work for some 2,000,000 persons in all.

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[4] H. A. Pritchard. Labour in Relation to Forestry in Great Britain. Papers presented at Third British Empire Forestry Conference, Australia and New Zealand, 1928. pp. 589–600. 1928.

FORESTS AS A SOURCE OF EMERGENCY EMPLOYMENT

Much has been said regarding the possibilities of forest work as a means of relieving unemployment during periods of economic depression. Such work has been used to good advantage in several States, notably California, Connecticut, New Hampshire, Massachusetts, Wisconsin, and New York during the last year or two. It has possibilities of great expansion.

It also has its limitations, particularly after forests are on a sustained yield basis. Most of the work incidental to protection, management, and exploitation must then be done currently and in fairly even volume. Planting cannot be expanded quickly to meet emergencies, because the planting stock has to be grown in nurseries for 1, 2, or 3 years or even longer before it is ready to set out. It is impossible to raise surplus planting stock in advance and hold it in reserve until needed, because it is impractical to use trees more than 3 or 4 years old. Fire protection work depends largely upon seasonal conditions. Slash disposal, where necessary, must be done soon after the timber is cut, hence is governed largely by the rate of cutting. Thinnings and improvement cuttings in properly regulated forests cannot be postponed indefinitely until a depression happens along, but must follow a fairly regular schedule. The rate of timber cutting in general is bound to be curtailed, not expanded, during depression periods, thus releasing large numbers of woods and mill workers. In Germany, unemployment in the forest and woodworking industries at the present time is worse than in most of the other industries.[5] As for the technical foresters, not only has the state forest personnel been reduced, but it is reported that more than 2,000 foresters in private employment have lost their jobs.

However, our forests in their present unregulated and undeveloped condition do offer opportunities for a large amount of emergency employment. There is great need for permanent improvements such as roads, trails, telephone lines, firebreaks, recreation facilities, lookout towers, and the elimination of fire hazards, such as standing dead snags and accumulated slash. In many localities there is urgent need for check dams, terracing, and forest planting to check erosion. Most of our forests are in need of improvement cuttings to remove defective, diseased, or otherwise undesirable trees and thus increase the yields of better quality timber. Much can be done to clear up breeding places for insect pests and tree diseases. Forest planting on a much larger scale than hitherto will be needed, even after the depression is over, hence it would be possible now to employ many men in establishing nurseries and preparing planting sites.

According to a recent survey by the American Tree Association, the National and State forests could, if funds were made available, give work to at least 70,000 men for a year, or to a much larger number for shorter periods. This estimate is believed to be extremely conservative. According to later estimates, a much greater number could be employed. It is also estimated that about three times as much work could advantageously be done in privately owned forests.

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[5] Lemmel. Die Wirtschaftsergebnisse des Preussischen Staatsforstverwaltung im Jahre 1930. Mitteilungen aus Forstwirtschaft und Forstwissenschaft 3:15–95. 1932.

Work of the character outlined is peculiarly suitable for times of depression when consumers' buying power is insufficient to absorb the products of industry. The increase in buying power resulting from such employment will not be immediately offset by the production of other goods which must be sold, as would be the case with artificially stimulated factory employment. Instead, the money spent in forest development work will go largely for wages and consumers' goods, and consumption of farm and factory products will be stimulated.

As noted above, a depression is apt to hit the forest industries as hard as any group of industries, even when forestry is on a permanent basis. Emergency employment in forest development is especially well adapted to give work to persons who have temporarily lost their jobs in the lumber and allied industries in the same locality. It will help workers to maintain their homes and to have reasonably steady occupation, and will prevent their drifting away and aggravating unemployment elsewhere. This is particularly desirable in regions where forestry and agriculture are closely interdependent. A combined forest and farm economy is more nearly depression-proof than an urban factory-mercantile economy, because the rural workers can to a considerable extent subsist by consuming their own and each other's products, even if there is no outside market for them. Unless the workers in the cities can sell their products or their services, they will have to be fed by the community or they will quickly starve.

FORESTS AND COMMUNITY DEVELOPMENT

BOOMS AND THEIR CONSEQUENCES

The "boom" phenomenon which follows too rapid exploitation and liquidation of natural resources follows a more or less generalized pattern. A boom centering around lumbering begins with the first logging operation in a virgin-timber area. Plant and equipment are quickly installed far beyond the sustained yield capacity of the tributary forests. Other logging operations and sawmills follow the first, and production gathers momentum as it goes. At the start, the new demand for goods and services commonly exceeds the supply. Local business which is in on the ground floor prospers and expands. The vacuum is rapidly filled by influx of new enterprises. Established agricultural and business enterprises adjusted to the demands prevailing before the boom reinvest their earnings in expansion of plant capacity. For a time all goes well, but sooner or later the boom collapses and these fundamentally sound enterprises necessarily face serious loss of capital.

In the history of booms—whether in mining, stock raising, lumbering, or recreation—few local governmental agencies have had the wisdom or the restraint to hold public expenditures in check. As the boom gets under way and as local agriculture and business prosper and expand, increases in taxes are accepted complacently by the taxpayers. Every community desires intensely to outdo some neighboring community in the excellence of its public buildings and its roads. As the income from taxes mounts, and without calculating the cost to complete, a program of public improvements is launched. Almost without exception, the original estimates of costs are far below the actual, and the final outcome is that bonds have to be issued to complete public projects that have been undertaken. Communities under the spell of optimism and local pride cheerfully vote bonds that their governing bodies say are needed. When the peak of the boom is passed, property values decline, and the burden of local taxation begins to bear heavily on the primary raw material industry and local citizens alike.

At this time taxpayer's leagues begin to form and endeavors are made to reduce public expenditures. Usually this is difficult, because of the unyielding nature of the fixed charges for maintenance of buildings and roads and for interest and amortization of bonds. Failing in this, county authorities plead for National and State subsidies. Ordinarily these are obtained, on the plea that collapse of local government's credit and default on bonds must be prevented.

This boom process of too rapid exploitation reacts in a broadly similar way on the individual lumber business. Each new operation that starts contributes toward overproduction. Usually two processes then come into operation. First, the major producers in the region attempt to work out some plan of price stabilization or production control. These attempts have invariably failed. Then the individual concern must begin to analyze production costs and attempt economies which will reduce the unit cost of lumber. These economies can be effected principally through increasing production so as to spread the fixed costs over a larger output. Increase in production frequently means increases in plant and equipment. Thus earnings are reinvested and become frozen assets. As operation after operation follows this formula, overproduction becomes progressively more serious, prices are further depressed, and net return is reduced. Savings in production costs are more than wiped out by decreases in selling price.

Somewhere in this phase of the cycle the local government begins the practice of assessing a fixed amount of taxes against an annually decreasing volume of stumpage. This still further accentuates the urge for quick liquidation and reduces the chance for the individual operator to come out even. More commonly than not, the latter phases of the cycle are a scramble to cut as rapidly as possible and to sell at any price. In the wake of depressed markets, credit becomes restricted and the need for cash forces still further lowering of prices. With the end of an operation it is often found that earnings have been largely reinvested and that the total capital investment has not been retired.

COMMUNITY DECADENCE FOLLOWS FOREST DESTRUCTION

Decline of lumbering is soon followed by decadence of agriculture in the region, and this in turn increases the difficulties for those who endeavor to hang on. The ultimate result is tax delinquency, land abandonment, or finally virtual depopulation of the region, with its train of economic and social wastage. The northern portion of the lower peninsula of Michigan may be taken as an illustration. For many years, while lumbering was flourishing, population steadily increased, homes were built, villages and cities grew up, a network of railroads spread over the region, and thousands of settlers established themselves on farms. Little thought was given to perpetuation of the forests, for it was believed that the region would develop as had the country farther south and that forests and forest industries would no longer be needed.

After a few decades logging and subsequent fires had wiped out all but a few remnants of the forests. The sawmills and logging camps which employed many thousands of men in 1889, employed only a few hundred in 1929. The railroads, no longer having timber to haul or anything to take its place, pulled out many of the branch lines and left the settlers without adequate transportation facilities. Costs of building and maintaining roads mounted, as did costs of schools and other public services. Real-estate values declined. Taxes were increased. The more prosperous portions of the State were called upon more and more to help support schools and highways. Farmers, no longer able to earn wages in winter work in woods or mills, with no local market for their produce, and burdened with rising taxes, found that they could no longer make a living and gradually drifted away. Between 1910 and 1930 the number of farms in the cut-over northern counties of lower Michigan decreased by more than 12,000, or 27 percent.

When the camps and mills ceased to operate, many villages and towns lost their principal or only industries and no longer had any reason for existence. Population fell off rapidly. Many mill villages that had had a population of several hundreds or even thousands joined the swelling list of "ghost" towns. One of the most striking instances is the twin towns of Au Sable-Oscoda, on the shore of Lake Huron. In 1890 these towns had a combined population of 8,346, with fine buildings, paved sidewalks, and all the conveniences of an enterprising small city. During the sawing season the population was much larger. In 1930 the combined population was only 903, of whom 61 lived in Au Sable city, which had 4,328 inhabitants 40 years before.

Of 31 counties in this region, 29 had fewer inhabitants in 1930 than in 1910 and 24 had fewer than in 1900. The region as a whole lost 83,000 people between 1910 and 1930, or 21 percent. During the same period the southern agricultural and industrial counties (not including Wayne) gained 765,000 inhabitants, or 50 percent, and Wayne County alone (Detroit and vicinity) gained 1,357,000, or 256 percent.

This state of affairs is not peculiar to Michigan. The same thing has happened in the other Lake States, in the Appalachian region, in the South, and already in some localities in the far West.

This entire boom cycle, starting with untouched virgin-timber areas and ending with local impoverishment and parasitism, has varied in length in different regions. But in the main the life of the cycle seldom lasts more than 25 to 40 years. It is disastrous alike to the lumbering business and to local communities, local government, and local business. To prevent booms, with their inevitable consequences of local impoverishment, overproduction, and migratory lumbering is one of the obligations of American forestry.

PERMANENT FORESTS SUPPORT PERMANENT COMMUNITIES

One of the most important contributions that continuously productive forests can make toward the general welfare is through the stabilization of centers or nuclei around which various economic and social institutions can group themselves. In these centers the workers in the forest industries can live with their families in their own homes instead of living in camps. They can be responsible citizens instead of the homeless, voteless men with little sense of civic responsibility who so often make up our transitory, "boom" logging camps and sawmill towns. Under these conditions villages or small cities can grow up, their size depending on the magnitude and variety of forest industries.

Such communities will furnish markets for nearby farmers and social and economic opportunities for them and their children and will tend to halt emigration to distant cities. The churches, schools, hospitals, public libraries, stores, places of entertainment, and other institutions which are provided in these centers and the contacts with persons of various occupations and points of view serve to widen the mental horizons and social opportunities not only of the villagers but also of the more scattered population in surrounding territory.

Without the industry centers, such institutions and services could not exist, or only on an exceedingly inadequate scale. Where the sawmills and industries are transient in character, as has so generally been the case in this country, the community nuclei are little better than camps, and the community services are not provided or they pass away with the cutting out of the tributary forests. Under such circumstances the social ill effects are greater than if the communities had never existed, because settlers are left stranded who would never have come into the region if they had not expected that permanent social institutions would be provided.

EXAMPLES OF PERMANENT FOREST-INDUSTRY COMMUNITIES

An excellent example of a community, or rather a group of communities dependent upon forest industry, is Grays Harbor County, in western Washington.[6] This county, with a population of 60,000, including several modern cities, is almost entirely dependent on the forest resources. In 1928 it had 52 lumber and shingle mills and 19 other enterprises manufacturing wood products. These, together with logging camps, employed over 10,000 persons. Millions of dollars have been spent by local interests and by the Federal Government in developing the harbor and port facilities for the shipment of lumber. There were 1,892 business firms in the county engaged in all sorts of enterprises. There were only 22,000 acres of crop and pasture land in 1928 out of a total area of 1,196,000 acres, but there were 956,000 acres of logged-off land. The total assessed valuation of the county in 1928 was close to $38,000,000, of which more than one half represented forest land, timber, and woodworking plants. Probably 90 percent or more of the other values would be wiped out if the lumber industry should cease. Obviously, the disintegration of such a group of communities or of others like these elsewhere would entail great economic loss, not only to those directly involved, but to the State and Nation as well. Fortunately, in this instance this has been realized before the forest was entirely exhausted, and plans for insuring a perpetual timber supply are being discussed.

Another example, in another part of the country, is the city of Bogalusa, in Louisiana, which has a population of more than 14,000 and is entirely dependent on forest-products industries. The 28 factories employ 4,400 men and ship close to 16,000 carloads of products a year. This is a city of fine homes, churches, schools, parks, playgrounds, and up-to-date business establishments. Starting as a lumber town, industries have gradually become diversified, and they now include pulp and paper, naval stores, woodenware, and furniture, but all of them are still based on the forest. The company controlling the principal industries has definitely embarked on a policy of growing timber sufficient to keep the mills supplied, so that this town, unlike so many other lumber industry towns, bids fair to be permanent.

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[6] Cooperative forest study of the Grays Harbor area (Washington). By various authors. 79 p. Published by Western Forestry and Conservation Association and Charles Lathrop Pack. (Portland, Oreg.) 1929.

A third example is the city of Cloquet, in Minnesota. Predominantly a sawmill town for almost a half century, its end appeared to be approaching, owing to depletion of the tributary saw timber, when it was practically annihilated by a conflagration in 1918. However, unlike the cities of Au Sable and Oscoda referred to above, which were similarly destroyed in 1911, Cloquet was rebuilt. Diversified wood-using industries were established to utilize material that the sawmills could not use, and efforts were made to perpetuate the timber supply. As a result, the city now has a population of approximately 7,000, or almost the same as before the fire. Besides sawmills, it has industries which make paper, balsam wool, boxes, toothpicks, refrigerators, clothespins, and various wood specialties. It has practically no industries except those based on the forest, and as only about 20 percent of the county's area is cultivated or improved pasture, Cloquet's future is inseparably linked with the future of the northern Minnesota forests.

LOCAL SUSTAINED YIELD IS ESSENTIAL FOR PERMANENT COMMUNITIES

These communities, though larger than many, are typical of the sort of communities that can be supported by permanently productive forests. No one will question the desirability, from every point of view, of a permanent existence for communities such as these. It is upon the thousands of comparatively small communities scattered throughout the country that the political and economic stability and social well-being of America depend. Neither these communities nor the larger metropolitan centers whose manufactures and commerce are based upon the products and resources of a prosperous, productive hinterland can continue to exist unless there is a continuous output of products from the land.

For one fourth of our land area this means a continuous output of forest products. It means more than merely maintaining a forest cover and insuring a crop of timber at some indefinite future date. As has been well said: "From the standpoint of timber supply alone it may be of little or no importance whether a continuous yield is maintained within the radius of a township, a county, a State, or even a major region of the whole country. With the consumer it makes no difference about the radius within which the annual cut is maintained. With the forest worker, however, it makes all the difference in the world." [7] If our forests are to do their part in maintaining permanent, prosperous communities, they must be handled in such a way that a continuous supply of timber is assured for each dependent community; that is, under the principle of sustained yield by comparatively small economic units. In this way unhealthy "boom" development can be avoided, periodic overproduction of lumber and other forest products can be prevented, all of the indirect benefits from the forests can be retained and increased, and our forests can take their place permanently as one of the basic natural resources upon which regional and national prosperity is founded.

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[7] Benton McKaye. Employment and natural resources. 144 p. U.S. Dept. of Labor. 1919.

FORESTRY AND PUBLIC FINANCE

The preceding discussion has shown that forestry serves the public interest in many ways, There would be little question as to the desirability of maintaining productive forests if they did not cost anything. But it is obvious that large expenditures will be required if our forests are to be protected and made fully productive. Hence it is natural that the questions arise: Will forestry pay? Can individual forest owners or the public afford forestry? Will not the cost, a large portion of which must be borne by the public, involve too heavy a strain on public treasuries and on individual taxpayers?

It can be admitted at the outset that forestry will not always, under all circumstances, show a cash profit to the owner, whether he be an individual or the public. There are large areas of forest land upon which forestry will not be profitable, unless in the remote future, particularly from the standpoint of the individual owner. This will be true of much of the less accessible land and land of relatively low productive capacity. It may also be true of the better land where the forest is so badly wrecked that a costly process of rehabilitation and a long period of waiting will be necessary before appreciable returns can be realized. Even for private owners, however, the opportunities for profitable forestry are much better than is commonly supposed. This is discussed in the section of this report entitled "Status and Opportunities of Private Forestry."

PUBLIC GETS RETURNS NOT AVAILABLE TO INDIVIDUALS

From the public standpoint, the prospect of direct financial profit from forestry does not have the same importance as with private owners.

Owners of forest land can obtain income from sale of wood and other tree products, grazing privileges, and recreational and occupancy privileges. Usually these are the only salable products as far as the private owner is concerned. If the landowner is also an operating lumberman, the profit he may make in the manufacture and sale of lumber is an operating profit, not a land-owning profit. He could make the same profit if he bought stumpage from another rather than from himself. Operating profit should not be confused with profits from landownership, though the two are commonly combined in one individual or corporation.

No matter whether land is in public or private ownership, the public receives indirect financial returns and other benefits that are not available to individual owners. Within suitable limits, therefore, the public is justified in spending money, both on public forests and to promote forestry on private lands, even where no direct return can be foreseen.

PRODUCTIVE FORESTS WIDEN THE TAX BASE

It is obvious that under the general property tax system there will be more property to tax with productive forests than with idle land, and that this will tend to result in lower tax burdens on all property within the same taxing unit. This additional property will include not merely the forests themselves, if they are privately owned, but also the sawmills, pulp and paper mills, and other plants dependent on the forest for raw material. It will include the homes and other property of persons employed in the forest-products industries, and the homes and businesses of persons who serve the forest-industry population. It will include the summer homes, resorts, and other recreation facilities that exist because of the forest. It will include the farms and villages whose existence depends on the forest. In the West it may include immense agricultural values that depend on the water from forest lands. These dependent values may, and often do, considerably exceed the values of the forests themselves.

In Wisconsin, for instance, the value of the pulp and paper plants is around $100,000,000. The wood for these plants could be supplied by about 2 million acres of managed forest which at present valuations would probably be worth not more than $50,000,000. In Grays Harbor County, Wash., forests and cut-over land are assessed at around $12,000,000 and lumber and woodworking plants at nearly $8,000,000. Of the remaining property, assessed at $18,000,000, at least 90 percent owes its value to the existence of the forest industries. Even the farms, now worth $1,000,000, would lose much of their value if the forest industries should close down permanently.

In cases like these, even if the forests themselves were entirely exempt from taxation they would indirectly return much greater revenues to the public treasury than would the same area of idle land. The same thing would be true if taxes were based partly or wholly upon incomes, instead of property. All of the varied industries and businesses sustained by productive forests are capable of yielding incomes, but idle land produces none.

Public acquisition of privately owned forest land is sometimes objected to on the ground that its removal from the tax rolls will reduce the public revenues. This might be a valid argument against public ownership if private owners could and would use the land in such a productive manner as to derive an income much larger than public agencies might derive from managing the same land. This will seldom be the case. In the long run, the tax collected by the public must be somewhat less than the net income from the land, or else private owners will not continue to hold it. With public ownership the public gets the entire net income.

Even where there is no direct income from a forest, the public may still derive a large indirect income. An extreme example is the Angeles National Forest in southern California. This forest is maintained primarily for watershed protection and not for timber production. It returns very little direct income, hence impairment of its protective value would not directly affect the income to the public treasury. However, the possibility of agricultural use of some 200,000 acres of exceedingly valuable land depends on the water from the Angeles Forest. It has been estimated that the Federal Government alone derives approximately $200,000 a year from taxes on incomes produced by these lands. The incomes from property taxes received by local governments are many times this figure.

This is an excellent example of a case where private forestry would not pay, but where public forestry produces indirect returns many times as large as the costs to the public.

PRODUCTIVE FORESTS REDUCE PER CAPITA COSTS OF PUBLIC FUNCTIONS

Another way in which productive forests benefit the public as a whole and large numbers of individuals, but only in a small degree the owners of the land itself, is a corollary of the preceding.

The per capita cost of various local public functions, such as schools, local government, and highway maintenance will to a certain extent vary inversely with the population served. For instance, the cost of maintaining a school for 20 pupils is not appreciably greater than for 3. It has been found in Wisconsin that rural schools with 5 pupils or less cost twice as much per pupil as schools with 10 pupils, and six times as much as schools with 25 pupils. A mile of road serving many settlers costs no more to construct and maintain than a mile serving a single isolated farmer. Costs of town and county officers, maintenance of a courthouse, jail, and public records, etc., are about the same whether the population is sparsely scattered or dense. Where, as in many instances, permanent forest industries can result in a settled population 2 to 3 times as great as would be supported by agriculture alone, each individual's or family's share in government costs is correspondingly reduced, or better service is rendered, or both.

WITH PRODUCTIVE FORESTS, LOCAL UNITS NEED LESS STATE AID

Conversely, the cost of supporting schools and other public services which have been established during a boom period of forest exploitation becomes exceedingly burdensome to the remaining taxpayers after the tax base has been narrowed by depletion of the forests and passing of the forest industries. This has happened in hundreds, if not thousands, of communities in every forest region of the United States. In many instances this situation has necessitated an extension of State aid to the financially weak communities, and has thus increased the tax burdens of other communities than those directly concerned.

One example is the State of Michigan, where almost every county in the cut-over region receives more money from the State school fund alone than it pays in State taxes. Besides this, the State contributes large sums for the construction and maintenance of roads. Similar conditions occur in numerous other States. The only way in which such financially dependent counties can become self-supporting—short of complete depopulation or breakdown of essential governmental responsibilities—is by eliminating uneconomic expenditures through more systematic land use and distribution of population so as to avoid unnecessary expenditures for schools and roads, and by increasing taxable wealth or sources of revenue through productive utilization of natural resources, particularly forest land. Unless these things are done, the States can look forward to a steady increase in contributions toward the costs of local government.

GREAT EXPANSION OF FORESTRY IS JUSTIFIED

To the question "Is forestry justified?" a general answer "yes" is indicated. This answer necessarily anticipates conclusions, based on detailed factual material which is contained in other sections of this report.

FORESTS A NATURAL RESOURCE OF MANIFOLD VALUES AND SERVICES

It has been shown that forests furnish a variety of useful raw materials which serve as the basis for important industries as well as for export and which can be reproduced indefinitely. They furnish useful employment and a means of subsistence to millions of our citizens. They protect the soil on river banks, hillsides, and mountain slopes. They retard or prevent the silting up of navigable channels, harbors, and reservoirs. They help to maintain the purity of domestic water supplies. They furnish forage for domestic livestock, and food and refuge for many forms of wild life that are useful to man or that afford him enjoyment. They beautify the landscape, and afford opportunities for inexpensive and wholesome recreation to many millions of people. They are an important adjunct of agriculture, which could hardly exist in many regions were it not for the forests. Under permanent management, they serve to prevent unhealthy booms, stabilize industry and social institutions, and sustain permanent communities.

NATIONAL WELFARE DEMANDS BEST USE OF OUR LAND RESOURCES

Forest land is almost one third of the land area of the entire country, or some 600 million acres. Failure to develop and utilize this land productively means inevitable reduction in the aggregate of goods and services available to satisfy the wants of our people. The only valid excuse for not so utilizing it would be that there are other, more useful or more productive outlets for all of our available efforts and energies. This patently is not true, in view of the already large and constantly growing chronic unemployment of our workmen and our industrial plants.

States and Nation are necessarily concerned with maintaining abundance of natural resources, as a source of basic national wealth and as a means of giving opportunities for employment to their citizens. Assurance of continuous supply of the raw materials produced by our own forest lands is in itself a national necessity. Undue dependence on foreign imports for materials that we can produce at home is not good national economy. Forest products are an important item in our international trade. Even the most localized areas of idle or partially idle forest land are of national concern, because thereby the sum total of national wealth is reduced, and the opportunities for employment are diminished. National economic well-being and security cannot be assured so long as local impoverishment and decadence are common.

FORESTRY THE BEST USE FOR LARGE AREAS OF LAND

During the pioneer period many scores of millions of acres of productive farms were carved out of forests. Originally, nearly all of the land east of the Great Plains was forested, and the pioneer farmer necessarily acquired a farm by destroying the forest. Thus the idea became firmly intrenched that all, or nearly all, forest land was suitable for agriculture after the forest was removed. As extensive lumbering operations spread in the Lake States and the South it was generally believed that agriculture would permanently utilize the cut-over lands. Land colonization became an accepted sequel to logging.

Experience rapidly demonstrated, however, that on millions of acres of forest land agriculture could not succeed. On large areas in the Lake States, in the South, and in the West, the idea that any kind of agriculture was feasible had to be given up.

Meanwhile, there has been widespread abandonment of agricultural lands which had been farmed for generations. The Northeast, the Piedmont Plateau, the southern Appalachians, and the Ohio Valley in particular have been the scene of widespread farm abandonment. Reduced fertility or usability caused by erosion has been a prime factor in removing millions of acres of hill farms from cropping. In those regions most of the cropped land was originally forested; much of it is likely to revert to forest.

The Bureau of Agricultural Economics (see section "Agricultural land available for forestry") estimates that the following areas have passed out of agricultural use since 1910, within those portions of the eastern United States that were once forested and are available for reforestation.

	Acres
Cleared land on abandoned farms	25, 000, 000
Idle crop land on farms not yet abandoned	10, 000, 000
Unused, nonwooded pasture land	15, 000, 000
Total	50, 000, 000

This does not include land which has come up to young timber and is now classified as forest. Furthermore, the bureau estimates that 30 million acres additional will cease to be used for crops or pasture between now and 1950. Partially offsetting this will be land that may be cleared for agricultural use. This is not likely to be a very large area. Agricultural economists state that—

> If these economic and technical forces continue to act as they did during the decade 1920–30, it will not be necessary to increase appreciably the total area of agricultural land or of crop land to provide the increased agricultural products required by the expected increase in population.

Agriculture evidently cannot be expected to utilize, either for crops or for pasture, any large area of lands now in forest, so that in the future it must be a case of forests or nothing. Constructive treatment of the agricultural lands being abandoned and the lands now forested will have to be under the practices of forestry, whether the purpose is timber production, watershed protection, recreational use, wild-life production, or some combination of these.

PUBLIC INTERESTS SHOULD DETERMINE EXTENT OF FORESTRY EFFORT

The justification for forestry does not depend finally on a meticulous calculation of the exact percentage at compound interest which each minor area of forest land can produce. Calculations of direct financial return may be acceptable in showing whether a private owner can retain his forest property. But the mere fact that a forest may offer little or no prospect of profit to the private owner should not be the deciding factor in planning its future use. The final determination, based upon a careful weighing of all the factors, including the public values involved, should rest with public, not private, agencies. The National Government, the State governments, and communities must consider as well the increased public income, the opportunities for self-supporting employment, the financial and social values of settled and permanent communities, the national advantages of home-grown forest products for domestic and export use, and the uncalculated but real values of forests in watershed protection, for recreational use, and in game production. The mere fact that forestry may not be justified for many private owners or the fact that they may think it is not, is not a point of much evidential value to the public agencies.

This statement, like any generalization on an economic question, cannot be taken to mean that the evidence shows or the Forest Service asserts the necessity for forestry on every acre of forest land, regardless of financial considerations. Such an assertion or reading of the evidence would be a manifest absurdity. But there is definite need for a very great and prompt increase in the acreage of forest land handled under the principles and practice of forestry.

PUBLIC CAN AFFORD AN ADEQUATE FORESTRY PROGRAM

Public interest in forest problems has been increasing steadily during the past 40 or 50 years, and much progress has been made. The concrete and solid steps in forestry include the establishment of the original national forest system in the West through reservation of public lands; its extension to the East through purchase; establishment and expansion of State forests in many States; development of State, Federal, and private owners' cooperation in fire control effort; adoption of laws making a start toward regulation of private land treatment in many States; forestry practice on some private land; establishment of schools for training of foresters; and a great increase in research and other activities, which are building up a factual foundation for forestry practice.

All of these are good, but they are not enough. The tempo of forestry effort needs to be speeded up before it is too late. The 50 million acres which agriculture has already given up after trying to use it profitably; the 60 million acres of devastated forest land; the nearly 250 million acres of cordwood and ragged but partially stocked cut-over forest lands; the whole regions from which too rapid exploitation of the basic resource of timber has driven self-sustaining agriculture and community life; the generally unsatisfactory level of the essential activity of fire control; the wide-spread depreciation of watershed and recreational values of forest land; the continuing reduction in yield capacity of our forests; the unstable position of important forest industries; all of these call for a comprehensive forestry program on a far greater scale than has been attempted hitherto.

Private owners generally will not, nor should they be expected to expend their money and efforts for purposes which will benefit them very little. It is logical and reasonable that the costs of such activities should be borne by the public which derives the benefit. These public benefits from forestry will be very large and widely ramified. The immediate costs to the public will also be large, but in the long run the direct and indirect returns to the public will be far greater.

PUBLIC CANNOT AFFORD TO DELAY ACTION

The Nation cannot afford to wait longer for existing efforts and the fortuitous play of economic forces to solve the problem. Only conscious, deliberate, and planned forestry on a large scale can measurably meet the known needs. Accidental or unconscious or unplanned action may, as in the past, leave some forest values on large areas. This something is better than nothing, but is doing only one fourth to one third of the job.

The total effort to date has not solved the problem, and the depression clearly has already had the effect of slowing down the existing rate of both private and public efforts.

Usable forests simply cannot be produced in a short time. Many decades are required even on the most productive areas, and with the most intensive forestry. The forest resources of the year 1980 depend on what is done now.

The numerous questions of how much forestry is now being practiced and by whom, the place and value of different means to forestry, the abilities and responsibilities of the different agencies, the costs and returns from forestry, the areas that will and may not be needed, and the program required in a full-scale attack on the problem are all discussed in later sections of this report.

THE FOREST-LAND RESOURCE

Forest land constitutes the basic and most fundamental element in the Nation's present and potential forest resources. In the first section of this part of the report the extent and character of our forest land are outlined by major forest regions and as to broad classes of ownership. Here is emphasized the peculiar and highly important multiple-use characteristic of forest land and the five major uses involved—timber production, watershed protection, recreation, production of forage, and conservation of wild life.

The second section considers the trends of agricultural land use and the factors which affect them, and estimates the areas of abandoned and other agricultural land available for forest use both now and as of 1950. It also sketches some of the social and economic losses involved in agricultural abandonment.

FOREST LAND THE BASIC RESOURCE

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EXTENT AND GENERAL CHARACTER

What is the forest-land resource of the United States? It consists mainly of about 495 million acres,[1] or one fourth of the land area of the continental United States (exclusive of Alaska), which may be capable of producing timber of commercial quantity and quality under present or reasonably conceivable future conditions (fig. 1).

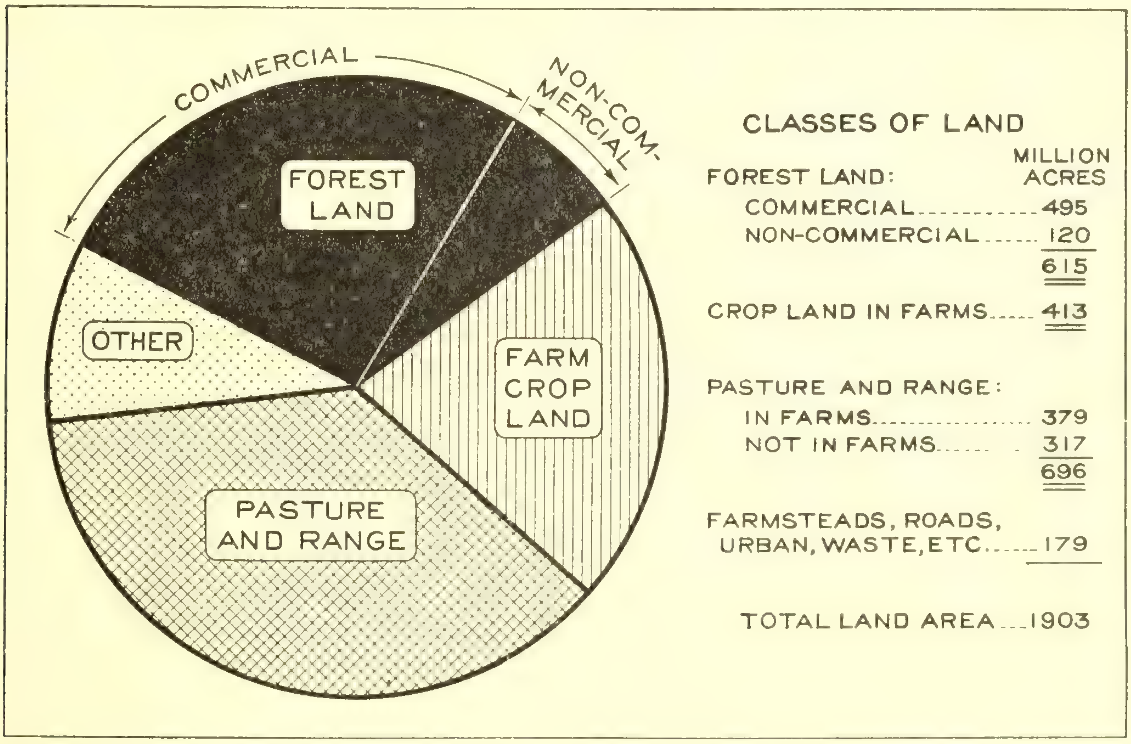

Figure 1.—Land area of continental United States (excluding Alaska) by major economic uses, 1929.

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[1] The data presented in this section and in the section, "Present and Potential Timber Resources", are based on a rapid extensive survey by the Forest Service in 1931, in which were tabulated forest areas, volume of standing timber, the rate at which the timber is growing, the annual rate of its use and destruction, and our actual requirements for forest products. In this compilation, the aid was employed of many cooperating agencies and individuals, the best available data were gathered and assembled, and the result checked with the judgment of well-informed men in the different forest regions. Although accuracy and consistency in detail are impossible in such an extensive survey, the broad general view of the forest situation thus made available will be valuable in the interim before the results of the more comprehensive and intensive Nation-wide forest survey now in progress by the Forest Service shall be available.

It includes also some 11 million acres of commercially valuable lands in the form of parks, preserves, etc., withdrawn from timber use; and 109 million acres of open-grown pinon-juniper lands in the West, chaparral in southern California, remote and inaccessible alpine ranges, and other areas which because of low productivity or extreme inaccessibility appear to be permanently out of the commercial timber-producing class (table 1). Much of this latter noncommercial land, which is inferior for timber production, has, however, a high value in terms of stream-flow control and prevention of erosion. The chaparral lands, for example, are extremely important in conserving the water supply for highly intensive agricultural projects. Figure 2 shows diagrammatically the arbitrary State groups which are used for statistical purposes. It shows also the principal types of forest.

TABLE 1.—*Forest areas of the United States, by broad classes and regions*

Region	Total	Commercial[1]	Noncommercial		
			Total	Withdrawn from timber use[2]	Chiefly valuable for purposes other than timber[3]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
New England	27, 434, 000	27, 273, 000	161, 000	79, 000	82, 000
Middle Atlantic	29, 770, 000	27, 139, 000	2, 631, 000	2, 467, 000	164, 000
Lake	60, 345, 000	55, 895, 000	4, 450, 000	2, 578, 000	1, 872, 000
Central	66, 059, 000	64, 249, 000	1, 810, 000	544, 000	1, 266, 000
South	216, 868, 000	190, 758, 000	26, 110, 000	589, 000	25, 521, 000
Pacific Coast	81, 295, 000	66, 685, 000	14, 610, 000	1, 753, 000	12, 857, 000
North Rocky Mountain	43. 187, 000	32, 329, 000	10, 858, 000	441, 000	10, 417, 000
South Rocky Mountain	89, 600, 000	30, 570, 000	59, 030, 000	2, 510, 000	56, 520, 000
Total	614, 558, 000	494, 898, 000	119, 660, 000	10, 961, 000	108, 699, 000

[1] Land capable of producing timber of commercial quantity and quality, and available for commercial use.

[2] Fair to good timber-producing land withdrawn from timber use, as in parks.

[3] Land characterized by scrubby or very inaccessible forest, such as pinon-juniper stands of the Southwest, scrubby mountain or alpine stands, and chaparral. Over 60 percent is publicly owned, some of which is withdrawn from timber use. Much of the area has an important value in protecting the watersheds of navigable streams, preventing or reducing soil erosion, protecting wild life, providing game cover, etc.

Forest land constitutes a basic and indispensable national resource. Upon its continued productivity depend a permanent and economically available supply of timber products, the maintenance of forest industries, and in turn the local prosperity based largely upon these industries. To grow the timber for lumber, pulpwood, fuel wood, fence posts, and the many other timber products demanded by modern civilization constitutes what we may term the timber use or timber supply function of forest lands. It represents their more tangible economic value or use.

Forested land affords benefits of far-reaching importance through its favorable influence in regulating stream flow, in preventing excessive erosion, and in providing shelter against wind and drought for homes, crops, and livestock. The sum of these protective influences constitutes one of the major uses of forested land.

Recreation, using the term broadly to include the entire range from simple picnicking and sight-seeing to prolonged wilderness camping, and the spiritual and inspirational stimuli afforded by nature's

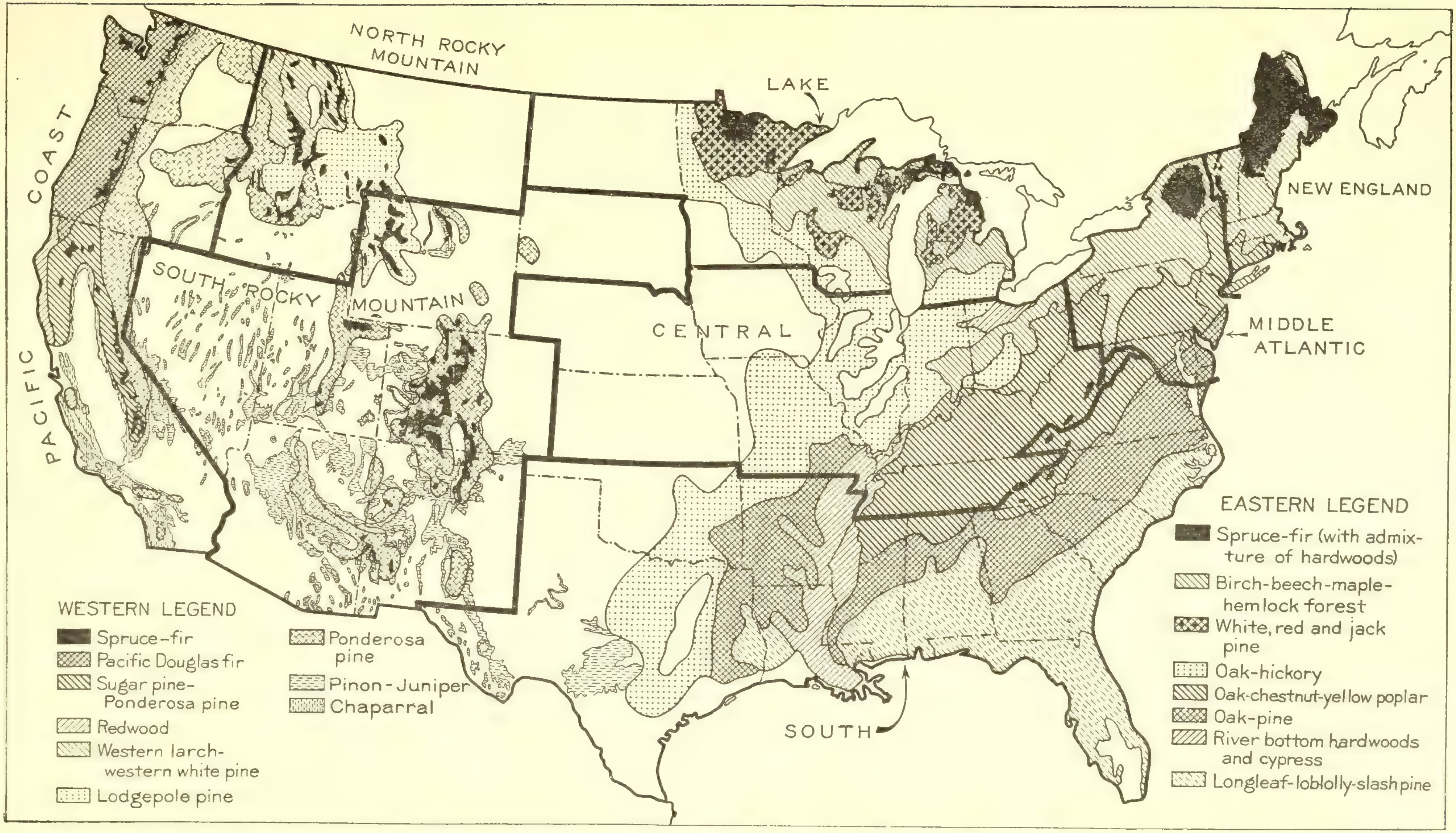
NORTH ROCKY MOUNTAIN
LAKE
NEW ENGLAND
COAST
PACIFIC
SOUTH ROCKY MOUNTAIN
CENTRAL
MIDDLE ATLANTIC
SOUTH
WESTERN LEGEND
Spruce-fir
Pacific Douglas fir
Sugar pine-Ponderosa pine
Redwood
Western larch-western white pine
Lodgepole pine
Ponderosa pine
Pinon-Juniper
Chaparral
EASTERN LEGEND
Spruce-fir (with admixture of hardwoods)
Birch-beech-maple-hemlock forest
White, red and jack pine
Oak-hickory
Oak-chestnut-yellow poplar
Oak-pine
River bottom hardwoods and cypress
Longleaf-loblolly-slashpine

FIGURE 2.—Forest regions and principal types of forest (based on forest cover map "Forests of the United States" by Zon and Shantz).

forested wonders, is now a major forest-land resource or function. Its importance is rapidly growing with the remarkable progress in transportation and communication, the reduced hours of labor, and the consequent increase in time available for recreation.

Forest lands furnish the environmental conditions in whole or in part upon which a large percentage of the game, fur bearers, and other wild life of the country depend. Affording as it does the basis for a large part of the commercial returns incident to game production, as well as for recreational hunting and fishing, wild life constitutes one of the basic forest-land resources.

Upon more than half of the forest lands of the country the forage produced by herbaceous and shrubby plants is grazed by domestic livestock. This range is an essential factor in the economy of countless livestock ranches, farms, and communities as now constituted. Forest range is then another major resource or use afforded by forest land.

The benefits afforded by the protection, recreation, game, and range uses of forest lands, though not so readily appraised, may well represent values to the public far greater in the aggregate than those to be realized from commercial timber. On specific tracts the values inherent in any one use may transcend those of all the other uses.

A notable and highly advantageous characteristic of forest land is that these major uses are not mutually exclusive. Forest land may at one time serve efficiently all of these uses. Exceptions, of course, occur where one or more should be excluded because of the highly specialized or intensive needs of others. For example, timber use is excluded from the national parks. But even there the forest land does not serve its recreation function alone, for it also affords protection benefits. Timber use is often excluded from municipal watersheds in the interest of full protection of city water supplies. Characteristically, then, forest land is a multiple-use resource par excellence, a fact which greatly enhances its economic value and all-round usability as a basic national resource.

Forest land will be considered in further detail with reference to these major uses. The greater length at which the timber phase of forest-land use is treated throughout this report is reflected in this section in the discussion of the timber use of forest land. The presentation under timber use is closely associated with other sections, and should be read in connection with some of the closely related phases, such as Present Timber Supplies and Timber Growth presented in the section "Present and Potential Timber Resources." The protection, recreation, game, and range uses dealt with briefly, following the discussion under timber use, are treated in full in the sections on those subjects.

FOREST LAND FOR TIMBER USE

ACREAGE, DESCRIPTION, AND DISTRIBUTION

Clearing land for agriculture was the largest single factor in reducing the original 820 million acres of comparable forest land in this country to the 495 million acres now available, theoretically at least, for commercial timber growing. In large part this conversion to a more intensive use constituted a natural and desirable economic trend, but it by no means indicated an indefinitely continuing process of converting timberlands to farms. A considerable area of converted land has already proved submarginal for agriculture. Furthermore, even during that early period when there existed the greatest popular demand for farm land in our history, scores of millions of acres of forest land were cut over or burned over and not brought into farms.

During the last decade or more an important and striking reversion has occurred in this trend nationally. The abandonment of agricultural lands has been the largest factor in a gradual but evident increase in forest areas. In certain regions, notably New England and the Middle Atlantic, this reversion commenced many years earlier. How extensive this change is, cannot be accurately estimated. The fact that the Forest Service in 1922, in a report Timber: Mine or Crop? (in United States Department of Agricultural Yearbook for 1922), estimated but 470 million acres of forest land—in contrast with the present estimate of 495 million acres—is not conclusive evidence on this point owing to the manner in which that earlier report was compiled; but there is reason to believe that the reversion of once cultivated land accounts for a considerable part of the difference between that estimate and the present one. This most recent increase in forest acreage is continuing. The reversion of other millions of acres of low-grade farm land is in progress or evidently pending. In all this process many perplexing questions of economics and of social standards or customs are involved.

Even allowing for some back-to-the-land movement as the result of the present economic depression, it is difficult to foresee any keen competition on the part of agriculture for large areas of forest land. On the contrary, it seems certain that our forest land, at least the area available for forest purposes, will materially increase. The section "The Agricultural Land Available for Forestry" estimates that 52 million acres are now available for forest use through agricultural abandonment or for other reasons and that this may be augmented by 25 to 30 million acres by 1950. Some of this land will in time become forested through natural processes. Some may be planted to forests. Most of it would fall within the commercial forest-land zone.

As will be evident in the later discussion, the term "commercial forest land" is used in a broad sense to mean not only land bearing present timber stands that could be economically utilized—for example, under the 1929 market and operating conditions—but also other forest land on which present or future timber stands can be economically utilized under reasonably conceivable future conditions. It will be shown in other sections of this report that appreciable areas of this commercial forest land will need to be withdrawn from timber use for recreational or other nontimber uses. In short, because of the prospective withdrawals for other major forest uses and because of the actual economic unavailability of the timber on much of the so-called "commercial forest land" under present and recent conditions, our effective forest-land capital for supplying our timber needs is now and may always continue to be considerably less than a half billion acres.

Neither our commercial forest-land acreage in the broad sense used in this report, nor in the narrower sense of land from which timber stands could now be economically utilized, can be considered stable. It will vary with the play of economic forces and changing social customs and usages. The effects of these changing conditions cannot be precisely foretold in terms of forest-land acreage. Of primary importance, however, are such questions as the quality and quantity of timber the forest lands will produce, whether these lands will be more or less than adequate for the best interests of our people, whether a national sufficiency will actually provide a regional sufficiency measured in terms of the forest products most needed, and to what degree public or private ownership of timber-use lands is to our best advantage. These and similar questions suggest the necessity for careful consideration of our commercial forest-land areas in the solution of many of the nation's major economic problems and in the planning of programs of forest-land use.

Table 2 and figure 3 show the distribution regionally of commercial land bearing timber of different conditions of growth—that of saw-timber size, that of cordwood size, of smaller growth on fair to satisfactory restocking areas, and, finally, the relatively unproductive areas termed poor to nonrestocking.[2]

TABLE 2.—*Commercial forest area of the United States, by character of growth and region*

Region	Total		Saw-timber areas			Cordwood areas	Fair to satisfactory restocking areas	Poor to nonrestocking areas
			Total	Old growth	Second growth			
	Thousand acres	*Percent*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	27, 273	6	13, 860	7, 976	5, 884	4, 843	6, 145	2, 425
Middle Atlantic	27, 139	5	7, 294	26	7, 268	10, 518	5, 998	3, 329
Lake	55, 895	11	5, 095	2, 664	2, 431	8, 880	28, 165	13, 755
Central	64, 249	13	21, 224	1, 664	19, 560	25, 592	12, 245	5, 188
South	190, 758	39	57, 265	14, 338	42, 927	52, 702	37, 236	43, 555
Pacific Coast	66, 685	13	44, 140	38, 892	5, 248	6, 683	6, 190	9, 672
North Rocky Mountain	32, 329	7	17, 026	15, 172	1, 854	5, 704	5, 933	3, 666
South Rocky Mountain	30, 570	6	22, 741	18, 123	4, 618	5, 959	161	1, 709
Total	494, 898	100	188, 645	98, 855	89, 790	120, 881	102, 073	83, 299

Commercial forest land is present in every major region of the United States in such quantity as to be an important basic resource. It will be shown in the section Present and Potential Timber Resources, however, that the populous and important wood-consuming New England and Middle Atlantic regions apparently cannot be wholly and permanently self-supporting as to timber supplies. They are now and probably will continue to be partially dependent, therefore, upon the South and West, a very favorable relationship insofar as the encouragement of forestry in the latter two regions is concerned. However, these interregional relationships account for numerous complexities in the formulation of regional and national forest-land policies.

Of outstanding significance, regionally and nationally, are the forest-land resources of the Pacific Coast, because of their potentially large timber-producing capacity and their enormous stands of virgin timber; and those of the South because of the great area (39 percent of the commercial forest land of the United States), the ease with which forests are renewed, their rapid growth, and the relative proximity to important consuming centers. The ultimate theoretical timber-producing possibilities of all the forest lands in these two regions, carefully managed, appear to be in excess of the consumptive capacity of these same regions as measured by current standards.

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[2] Saw timber denotes areas characterized by trees large enough for sawlog production regardless of their actual use. In recent years over 30 percent of the saw-timber cut has been used for other than lumber manufacture. Cordwood denotes areas characterized by trees too small for saw logs but large enough for cordwood use, regardless of whether the stand is cut for cordwood or held for saw timber. Good, fair, poor, and nonrestocking refer to areas characterized by 70 percent or more, 40 to 69 percent, 10 to 39 percent, and less than 10 percent, respectively, of normal stocking with trees for the most part below cordwood size.

Although the permanently productive use of forest land for timber purposes is in itself highly desirable, this is economically feasible, insofar as timber supplies are the primary purpose, only if the timber can be marketed profitably. This points to the fundamental question, rendered temporarily more acute in the Pacific Coast region by the presence of large volumes of virgin timber, whether or not other regions of the United States and, for that matter, foreign countries can most advantageously and economically fill some of their own needs for timber products from the surpluses that can be grown and probably will not be needed in the South and West. Upon the answer to this question must partly hinge the justification for expenditures to keep all of the forest lands in these two regions permanently productive.

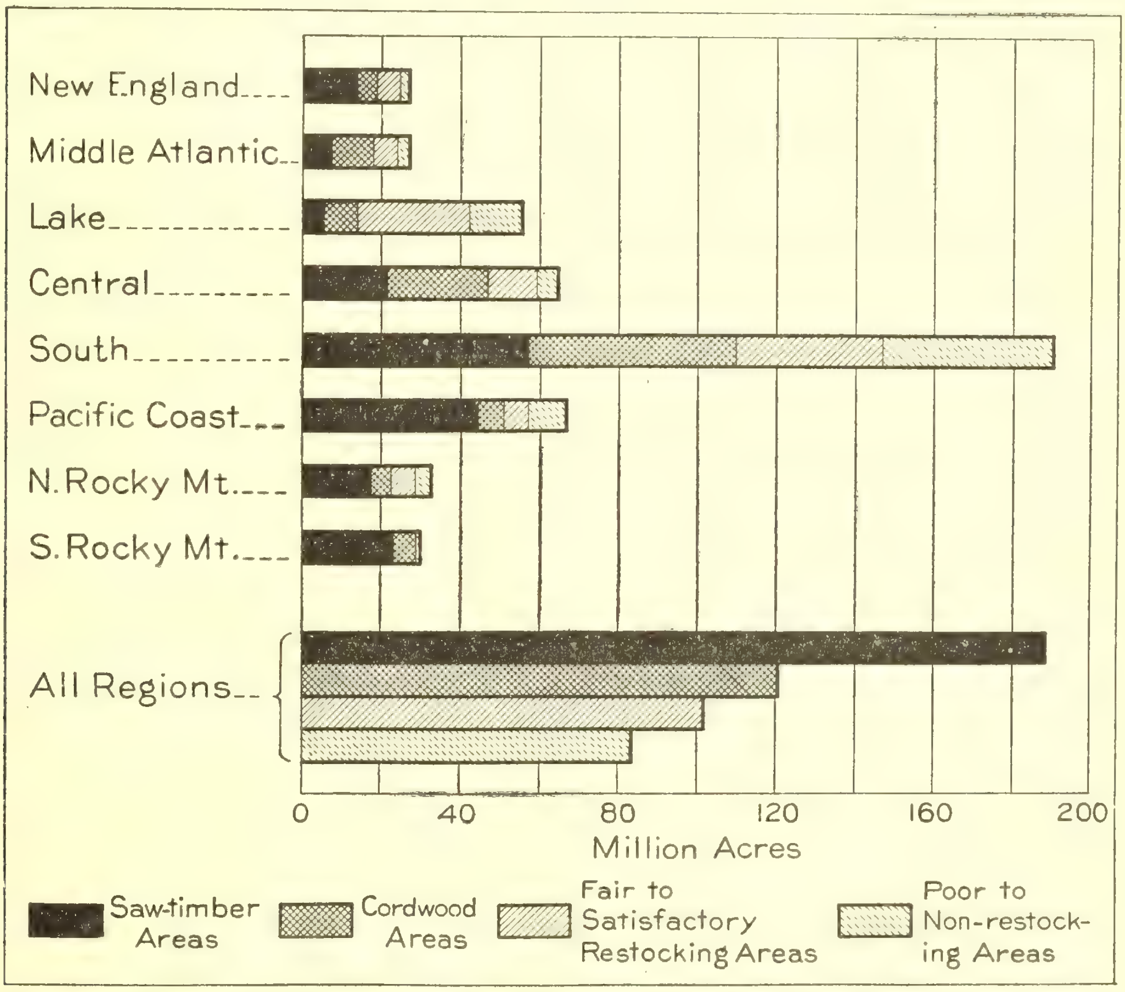

FIGURE 3.—Forest area (commercial) of the United States by region and character of growth.

Parenthetically, the authors hazard the opinion that with such interregional dependence for timber supplies, the United States as a whole is not likely to use as much timber as would be used if all regions had ample supplies at home. It is believed that proximity to abundant forest supplies and to wood-using and other forest industries tends to make people forest conscious and apt to consume more timber and timber products than they would if these must be brought from distant points even though at reasonable cost.

The 189 million acres of land bearing saw timber is divided about equally between old growth and second growth. The old growth is, of course, located mostly (see table 2 and fig. 4) in the three western regions with the Pacific Coast predominating, while the second growth is mainly in the eastern half of the country with the South far in the lead. The presence of these large areas of old-growth saw timber in the Pacific Coast region and of second-growth saw timber in the South does not, however, indicate correspondingly large volumes of timber available for cutting at present within these two great forest regions. The extensive second-growth lands in the South represent immature actively growing timber which is now being cut extensively, but which far more desirably should be retained as growing stock. On the other hand, western old-growth areas support heavy stands of mature, high-quality timber suitable for cutting. The desirable interregional coordination thus implied is discussed further in the section, "Present and Potential Timber Resources".

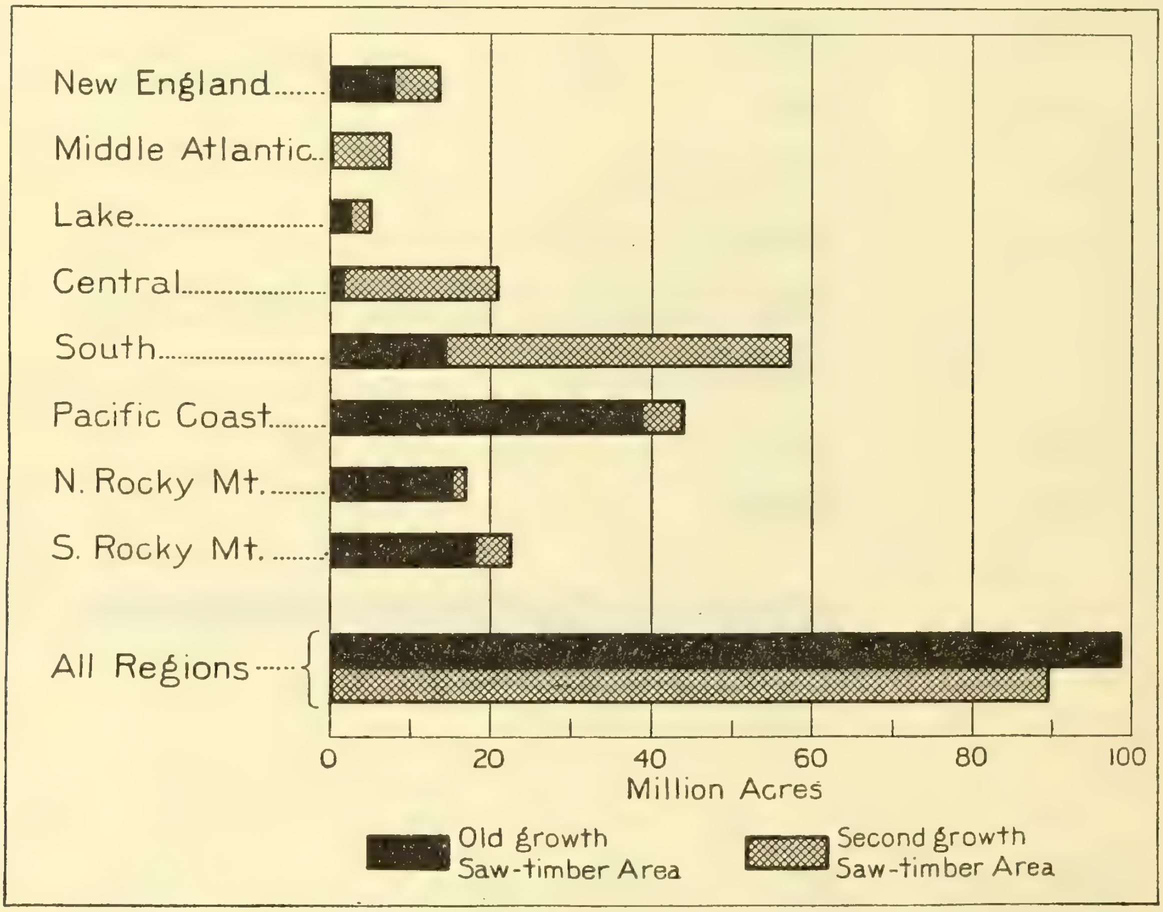

FIGURE 4.—Old-growth and second-growth (commercial) saw-timber areas by regions.

The great bulk—85 percent—of the 185 million acres of restocking and nonrestocking lands are, as would be supposed, to be found in the East. In fact they constitute 43 percent of all the eastern forest land. This is the type of forest land upon which fires have caused or may cause much serious though often unspectacular damage. From the standpoint of areas involved, the problem of protecting restocking land looms large in the eastern forest regions and more especially in the South. Similarly, the problem of artificial reforestation of already denuded lands is mainly an eastern one, possibly most serious in the Lake region. Figure 3 and table 2 indicate, however, that except for the southern Rocky Mountain region with its insignificant areas of restocking and nonrestocking, the poor to nonrestocking exceeds the fair to satisfactory restocking by a larger percentage in the Pacific Coast region than anywhere else. It is common knowledge that adequate protection against fire on cut-over areas is, in every region, one of the most vexatious problems. Its solution, of course, is the sine qua non to keeping the forest lands in the Douglas fir type permanently productive.

Eighty-three million acres are classed as either poor or nonrestocking, of which the latter makes up 34 million. Although it is possible that as much as a fourth of the area of 83 million acres will produce some commercially valuable saw timber within the next saw-timber generation, no such hope is believed tenable in the absence of planting for the remaining 60 million acres and more. This great area, idle largely because of fires and improvident logging methods, constitutes a most serious feature of the forest situation. Except as it may be restocked by artificial means and at large expense, it seems likely to have little timber-producing significance for many years. In other words, as a practical proposition, this area will, unless artificially restocked, reduce for many years to come and to a very considerable extent the commercially effective forest land capital.

The wide differences in proportionate distribution of forest land in the different regions according to conditions of growth or broad age classes is illustrated by figure 3. The Lake region is characterized by a strikingly large proportion—42 million acres of a total of 56 million, classed as restocking or nonrestocking in comparison with only 5 million of saw timber and 9 million of cordwood. The generally recognized fact is here clearly shown that the eastern regions are nearly always characterized by a much lower proportion of saw-timber land than are the western regions.

OWNERSHIP OF COMMERCIAL FOREST LAND

The character of forest land ownership is especially important from several standpoints. It affects the owner's interest in the land as distinct from the merchantable timber; his willingness to handle his property so as to keep it continuously productive; and his ability to bear the long-time financial burden required to produce commercial crops on land from which the growing stock has been removed or severely depleted.

Where the timber of a whole region is cut off in a short period of time, even though all the forest land is restocked promptly with commercial species, the industries and the people depending on them must move to other localities. After a new crop of timber matures new industries may be established and the process repeated. Such intermittent industry entails great waste of raw material, high depreciation charges for plant and operating facilities, and disastrous and far-reaching disruption of the economic and social structure. If, so far as timber products are concerned, forest lands are to be most effectively used, if forest regions are to be permanently productive and the homes of stable prosperous populations, their wood-using industries and towns must be established on a permanent basis. And so it is that a system of management of forest lands that will result in a region as a whole, a locality, or even a single ownership supplying merchantable material continuously—in other words, a system of sustained yield management—is highly desirable. One important gauge of land ownership is, therefore, how well it adapts itself to sustained yield management.

INDUSTRIAL OWNERSHIP

Industrial ownership is the most important type of forest land ownership in the United States, not only because it includes over half of the commercial acreage, but because it is here that the Nation's forest problems especially reside. Two hundred and seventy million acres (see table 3 and fig. 5), or well over half of the commercial forest land—by and large including the best—is owned by land, lumber, pulp and paper, and mining companies, naval stores operators, railroads, and miscellaneous individuals or agencies. With some notable exceptions these owners have not been convinced of the financial justification for the measures that would insure keeping this land continuously and permanently producing timber.

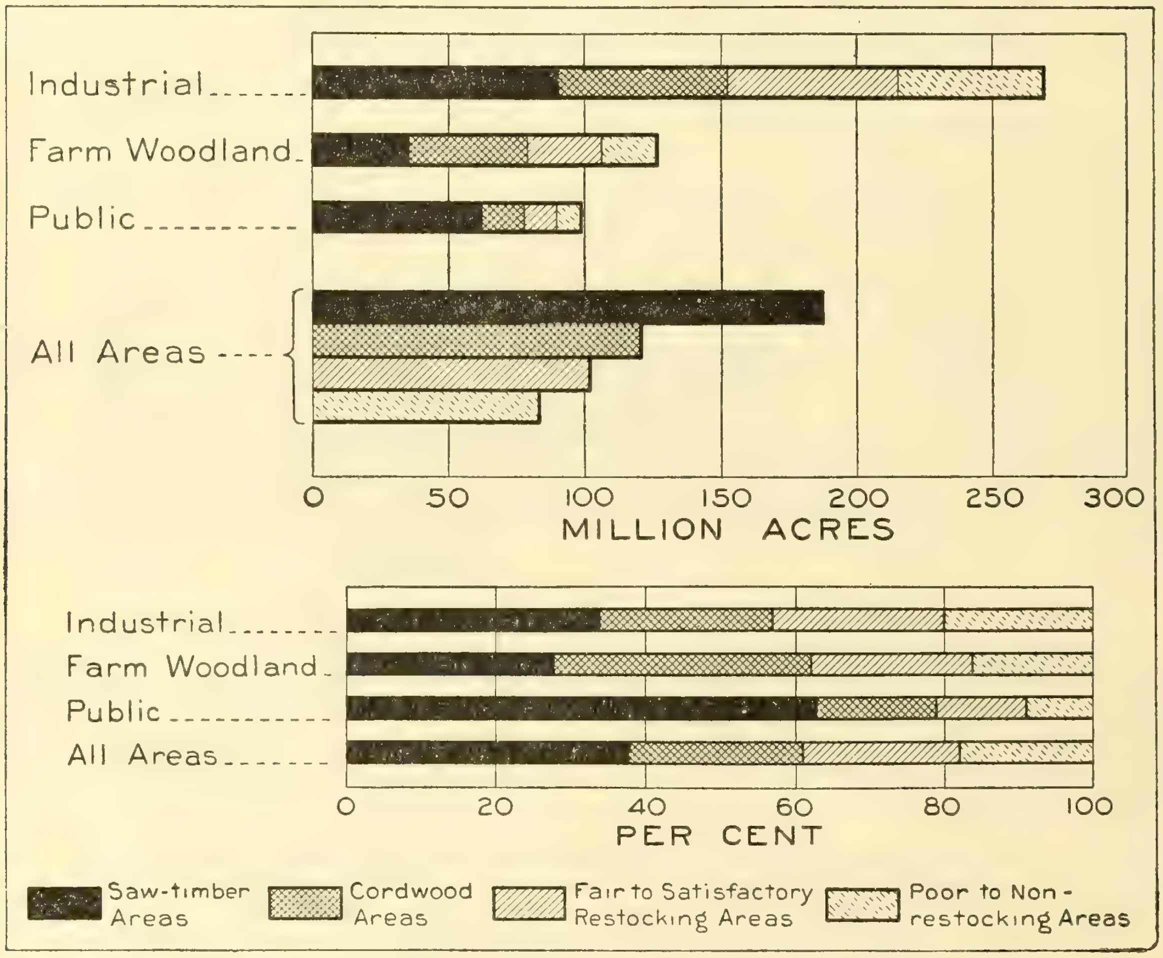

FIGURE 5.—Character of growth in each ownership class on commercial forest areas.

It is undoubtedly true that private forestry practice would have been and is now economically advantageous on a much broader scale than has been in effect. Nevertheless private owners face some very disconcerting problems and uncertainties in embarking upon forestry programs. The following might be listed as examples: Existing methods of forest taxation—especially the uncertainty as to the amounts that must be paid in the future before revenues begin to come in from those properties that are not now on a sustained or continuous yield basis; the danger of losses by fire and other destructive agencies against which existing protection is far from uniformly adequate, and for which commercial insurance is not commonly available at attractive rates; the unavailability of favorable long-time credits on a basis comparable, for instance, to that on which farm loans can be obtained; the uncertainty as to what changes a few decades may bring in the amount of timber products consumed or as to value in relation to costs of production—in short, the uncertainty of future returns; and beyond this the aversion of the average American to embarking on a long-time enterprise as against one which promises quick returns, even if the former appears thoroughly sound on its own merits.

TABLE 3.—*Ownership of commercial forest areas of the United States, by regions*

ALL AREAS

Region	All areas	Federally owned or managed				State, county, and municipal	Private		
		Total	National forest	Indian reservation	Other		Total	Industrial	Farm woodland
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	27, 273	471	471			824	25, 978	19, 576	6, 402
Middle Atlantic	27, 139	347	317		30	1, 861	24, 931	15, 470	9, 461
Lake	55, 895	2, 955	1, 800	1, 140	15	3, 867	49, 073	34, 792	14, 281
Central	64, 249	581	579		2	191	63, 477	31, 319	32, 158
South	190, 758	3, 213	3, 137	56	20	281	187, 264	129, 398	57, 866
Pacific Coast	66, 685	31, 811	26, 046	3, 413	2, 352	1, 837	33, 037	27, 938	5, 099
North Rocky Mountain	32, 329	23, 725	22, 036	833	856	1, 266	7, 338	5, 925	1, 413
South Rocky Mountain	30, 570	24, 924	20, 293	1, 986	2, 645	505	5, 141	5, 098	43
Total	494, 898	88, 027	74, 679	7, 428	5, 920	10, 632	396, 239	269, 516	126, 723
SAW-TIMBER AREAS									
New England	13, 860	248	248			351	13, 261	10, 834	2, 427
Middle Atlantic	7, 294	30	29		1	64	7, 200	3, 732	3, 468
Lake	5, 095	474	353	121		197	4, 424	2, 631	1, 793
Central	21, 224	220	218		2	83	20, 921	8, 763	12, 158
South	57, 265	1, 941	1, 884	49	8	104	55, 220	41, 491	13, 729
Pacific Coast	44, 140	24, 129	19, 852	2, 815	1, 462	1, 104	18, 907	17, 167	1, 740
North Rocky Mountain	17, 026	12, 623	11, 605	573	445	849	3, 554	3, 190	364
South Rocky Mountain	22, 741	19, 612	15, 606	1, 746	2, 260	351	2, 778	2, 744	34
Total	188, 645	59, 277	49, 795	5, 304	4, 178	3, 103	126, 265	90, 552	35, 713
CORDWOOD AREAS									
New England	4, 843	112	112			190	4, 541	2, 841	1, 700
Middle Atlantic	10, 518	48	40		8	772	9, 698	6, 085	3, 613
Lake	8, 880	578	510	68		469	7, 833	3, 226	4, 607
Central	25, 592	158	158			66	25, 368	12, 936	12, 432
South	52, 702	638	631	3	4	51	52, 013	32, 224	19, 789
Pacific Coast	6, 683	3, 476	2, 755	441	280	109	3, 098	2, 170	928
North Rocky Mountain	5, 704	4, 550	4, 296	112	142	129	1, 025	716	309
South Rocky Mountain	5, 959	4, 146	3, 567	222	357	127	1, 686	1, 683	3
Total	120, 881	13, 706	12, 069	846	791	1, 913	105, 262	61, 881	43, 381
FAIR TO SATISFACTORY RESTOCKING AREAS									
New England	6, 145	86	86			208	5, 851	4, 279	1, 572
Middle Atlantic	5, 998	140	131		9	786	5, 072	3, 348	1, 724
Lake	28, 165	1, 206	543	651	12	2, 276	24, 683	19, 284	5, 399
Central	12, 245	133	133			34	12, 078	6, 885	5, 193
South	37, 236	373	366	3	4	61	36, 802	24, 718	12, 084
Pacific Coast	6, 190	1, 610	1, 166	104	340	256	4, 324	3, 205	1, 119
North Rocky Mountain	5, 933	4, 226	3, 935	96	195	167	1, 540	1, 133	407
South Rocky Mountain	161	143	135		8	2	16	11	5
Total	102, 073	7, 917	6, 495	854	568	3, 790	90, 366	62, 863	27, 503

TABLE 3.—*Ownership of commercial forest areas of the United States, by regions*—Continued

POOR TO NONRESTOCKING AREAS

Region	All areas	Federally owned or managed				State, county, and municipal	Private		
		Total	National forest	Indian reservation	Other		Total	Industrial	Farm woodland
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	2,425	25	25	--------	--------	75	2,325	1,622	703
Middle Atlantic	3,329	129	117	--------	12	239	2,961	2,305	656
Lake	13,755	697	394	300	3	925	12,133	9,651	2,482
Central	5,188	70	70	--------	--------	8	5,110	2,735	2,375
South	43,555	261	256	1	4	65	43,229	30,965	12,264
Pacific Coast	9,672	2,596	2,273	53	270	368	6,708	5,396	1,312
North Rocky Mountain	3,666	2,326	2,200	52	74	121	1,219	886	333
South Rocky Mountain	1,709	1,023	985	18	20	25	661	660	1
Total	83,299	7,127	6,320	424	383	1,826	74,346	54,220	20,126

There is one important feature of private forest land ownership in the United States, not usually emphasized, which undoubtedly has an important bearing upon the management of forest properties. Data are not available for authentic estimates, but it is common knowledge that very large portions, particularly of the larger tracts

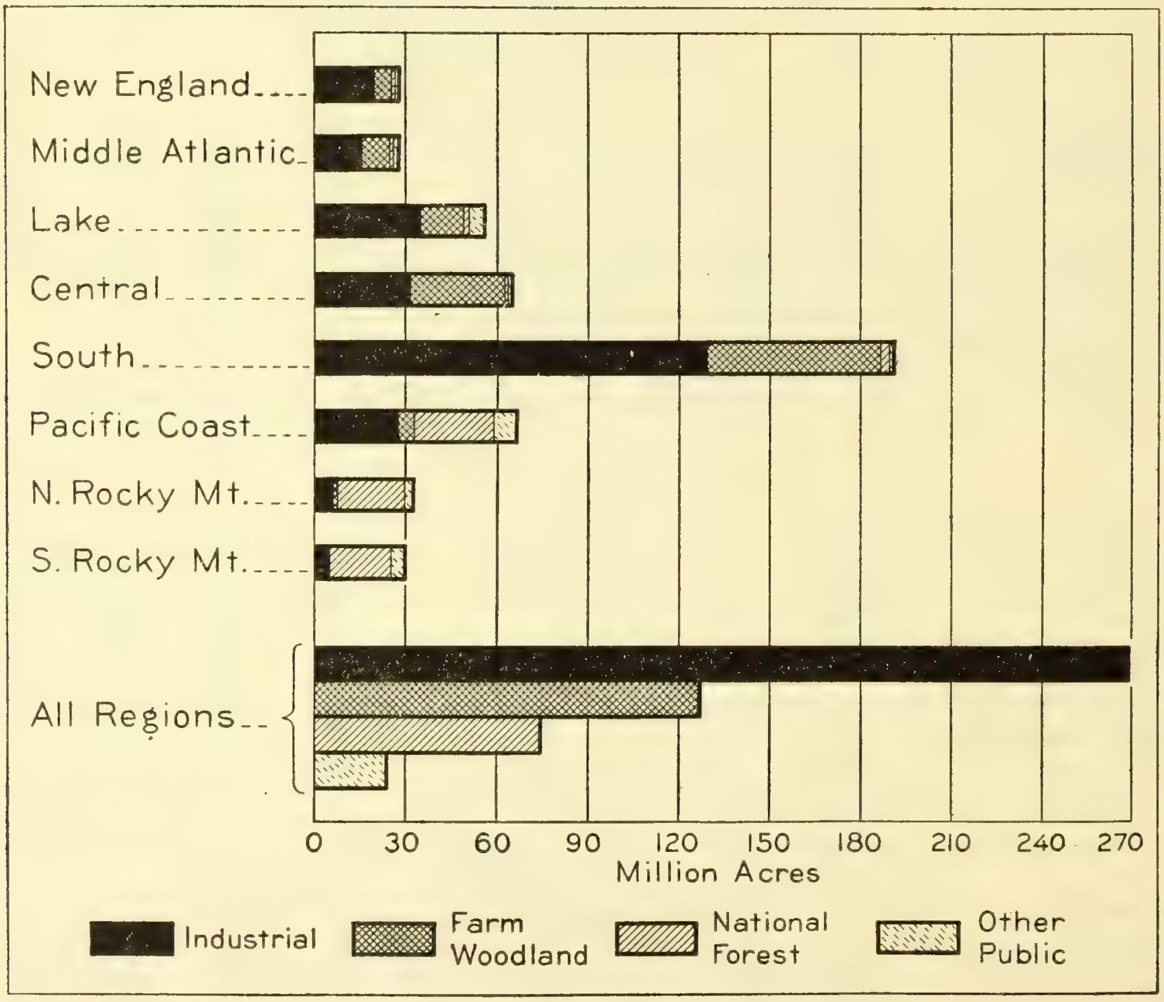

FIGURE 6.—Ownership of forest area (commercial) by regions.

of forest land, are owned by lumber manufacturers. The special problems of the forest property thus become involved with those of the manufacturing plant. This has both its advantages and disadvantages, but there is reason to think that in many instances forestry would be facilitated by complete separation of the forest-growing enterprise from the problems peculiar to manufacturing and marketing.

The generally known fact that industrial forest land ownership is the predominating type of ownership in the eastern regions, whereas public ownership predominates in the three western regions, is shown graphically in figure 6. Of the industrial acreage, 86 percent is in the East as against 14 percent in the West. Even so, the industrial ownership in the Pacific Coast region is very important both because it includes land that potentially is highly productive and also because considerable areas bear virgin stands, which are pressing for liquidation. The South includes nearly one half of the industrial lands for the entire country. In the Central region industrial ownership about equals that for farm woodlands, but elsewhere it is much in excess.

Figure 5 visualizes the distribution of age classes for industrial, farm woodland, and public ownerships, respectively, both on an acreage and on a percentage basis. It is apparent that the proportion of saw-timber area for industrial, though slightly more than for farm woodland, is much less than for public ownership. The contrast for industrial and public ownership would be greater if limited to old growth. On the other hand, the proportion of restocking and nonrestocking areas is notably larger for industrial, and somewhat larger for farm woodland than for public ownership. Such broad generalizations in themselves, however, may be misleading. The situation must be considered in the light of various influencing circumstances. For example, public ownership, including the extensive western national forests, still holds large areas of virgin timber cut over only in small part because of their inaccessibility and because of conservative selling policies. A more detailed view by regions is afforded by figures 7, 8, and 9.

The situation in New England in respect to age class areas needs some explanation. Over 50 percent of the area is classed as saw timber. This is because of the large areas of mixed spruce and hardwood forest in northern New England which have been culled for softwoods alone and now remain as an essentially unbroken old-growth hardwood saw-timber forest. Much of the old-growth hardwood thus classed as saw timber is of poor quality and largely inaccessible because of lack of transportation facilities other than the streams. The situation is in reality therefore not as favorable as appears from the figures; aside from this large area of almost inaccessible hardwood of doubtful quality the area of usable saw timber is relatively small. In the Lake region the situation is extremely acute. Less than 10 percent is saw timber, over 50 percent is fair to satisfactory restocking, and 25 percent is poor to nonrestocking. The significance of this is that forest depletion has gone so far in the Lake region that many years will be required to rehabilitate the growing stock to the point that a sustained yield in keeping with the productive capacity of the land can be attained. Other regions are intermediate. Industrial ownership in the South, for example, is characterized by a relatively large area in the restocking and nonrestocking classes.

It is noteworthy that 31 million acres, or more than half of the industrially owned area of poor and nonrestocking land in the entire country, is located in the South where also occur (see section, "Present and Potential Timber Resources") by all odds the largest proportionate acreage annually burned over and the greatest lack of organized fire protection. One of the most serious though less spectacular phases of forest-fire damage lies in the destruction of the small trees on restocking areas which, if burning be continued, soon relegates these areas to the nonrestocking or denuded classification.

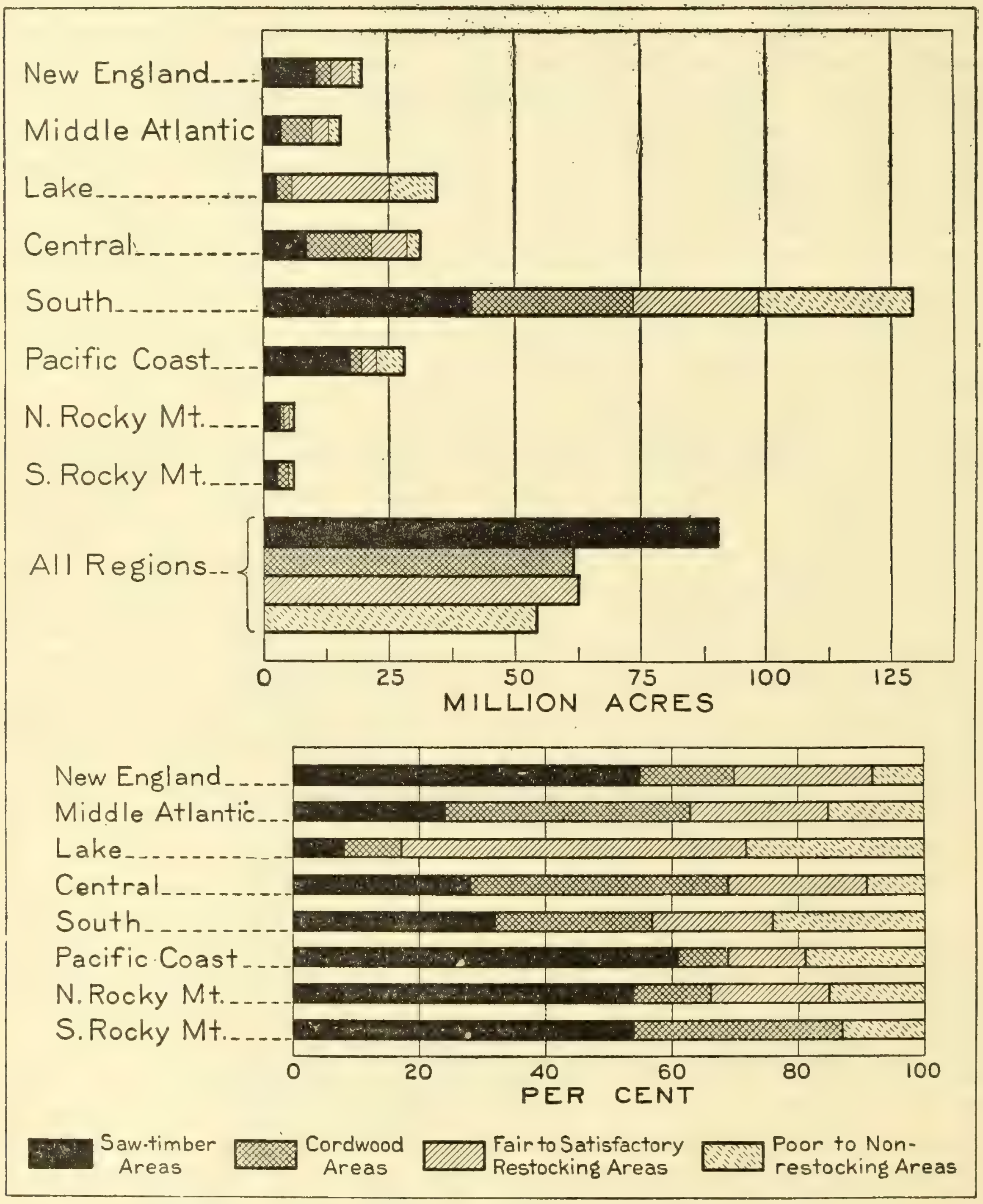

FIGURE 7.—Industrial forest area, by region and character of growth.

At the same time, it is significant that 63 million acres of industrially owned cut-over land is classed as satisfactorily or fairly restocking. This is indicative of the ability of most forest lands to restock naturally if given a fair chance, and it is undoubtedly in considerable part at least the fruit of organized fire protection and of the interest and efforts of individual owners in fire protection. With adequate care during and following cutting it would seem that future forest denudation could be held to very small proportions.

The large areas of cut-over land that are burned also reflect in part the usual lack of concern of private owners as to what happens to the future timber crop on land from which they have removed the present crop. This lack of interest is also illustrated by the fact that included in industrial land is the bulk of the 20 to 30 million acres of cut-over forest land which is already reverting to public ownership (much more is in prospect), usually through tax delinquency and which, supplemented by abandoned farm land, largely makes up the so-called "new public domain", which is treated at length in the section, "Breakdown of Private Forest Land Ownership." This, in several regions, is causing severe economic and social disturbances. It constitutes a rapidly expanding and difficult problem in land utilization and planning.

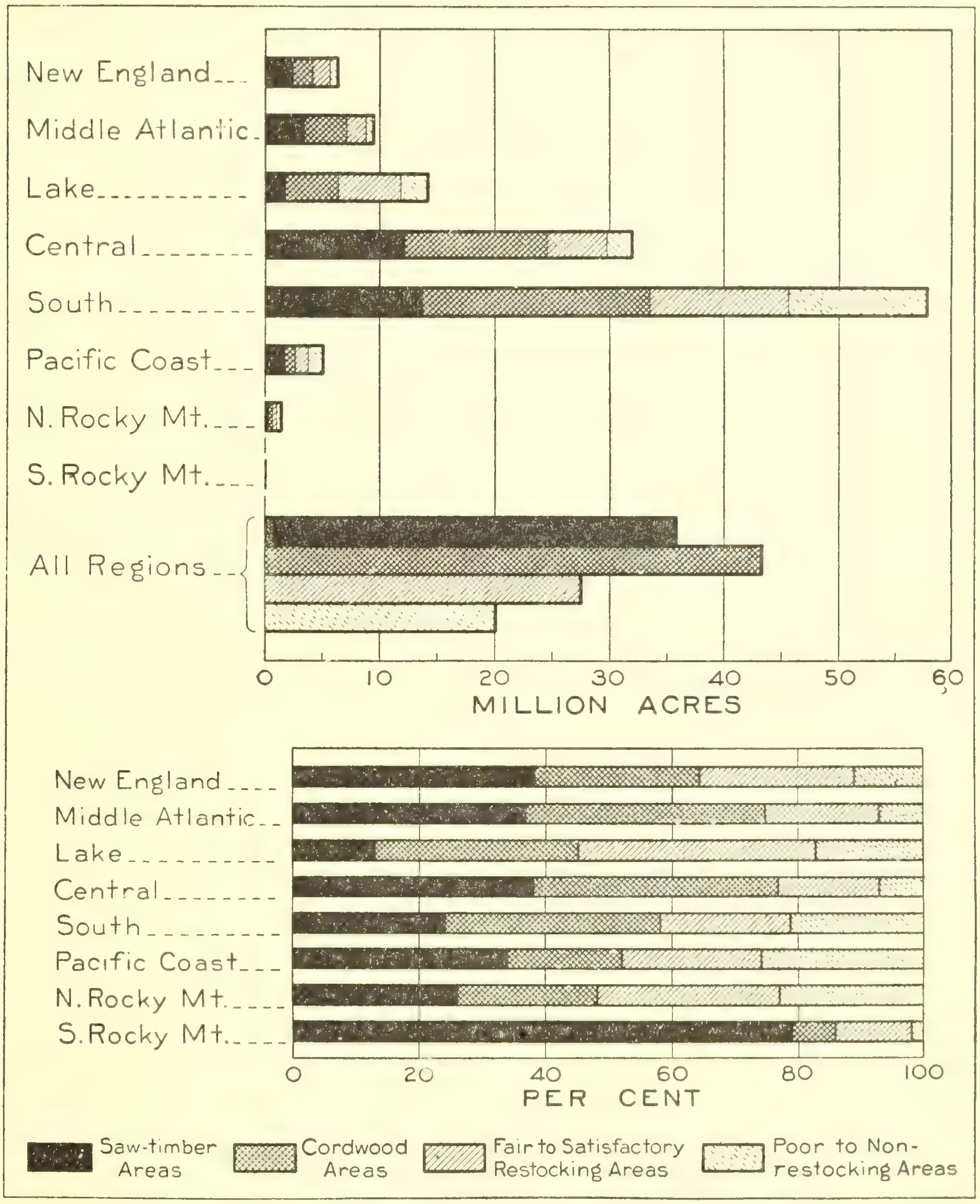

FIGURE 8.—Farm woodland (commercial) area by character of growth.

FARM WOODLANDS

Farm woodlands constitute a very important and distinctive type of forest-land ownership and one well adapted, generally speaking, to keeping forest land permanently productive.

More than one fourth of the country's commercial forest land, or 127 million acres, is in farm woodland and of this, 95 percent is in the eastern United States where it constitutes somewhat less than one third of the eastern commercial area. In the Central region it includes about one half and in the South and Middle Atlantic about one third of the commercial acreage. It is therefore in relative proximity, broadly speaking, to the great wood-consuming, wood-importing regions—a favorable factor, in that the most productive and profitable use of these lands depends upon markets to absorb the surplus timber products not needed for direct consumption on the farm.

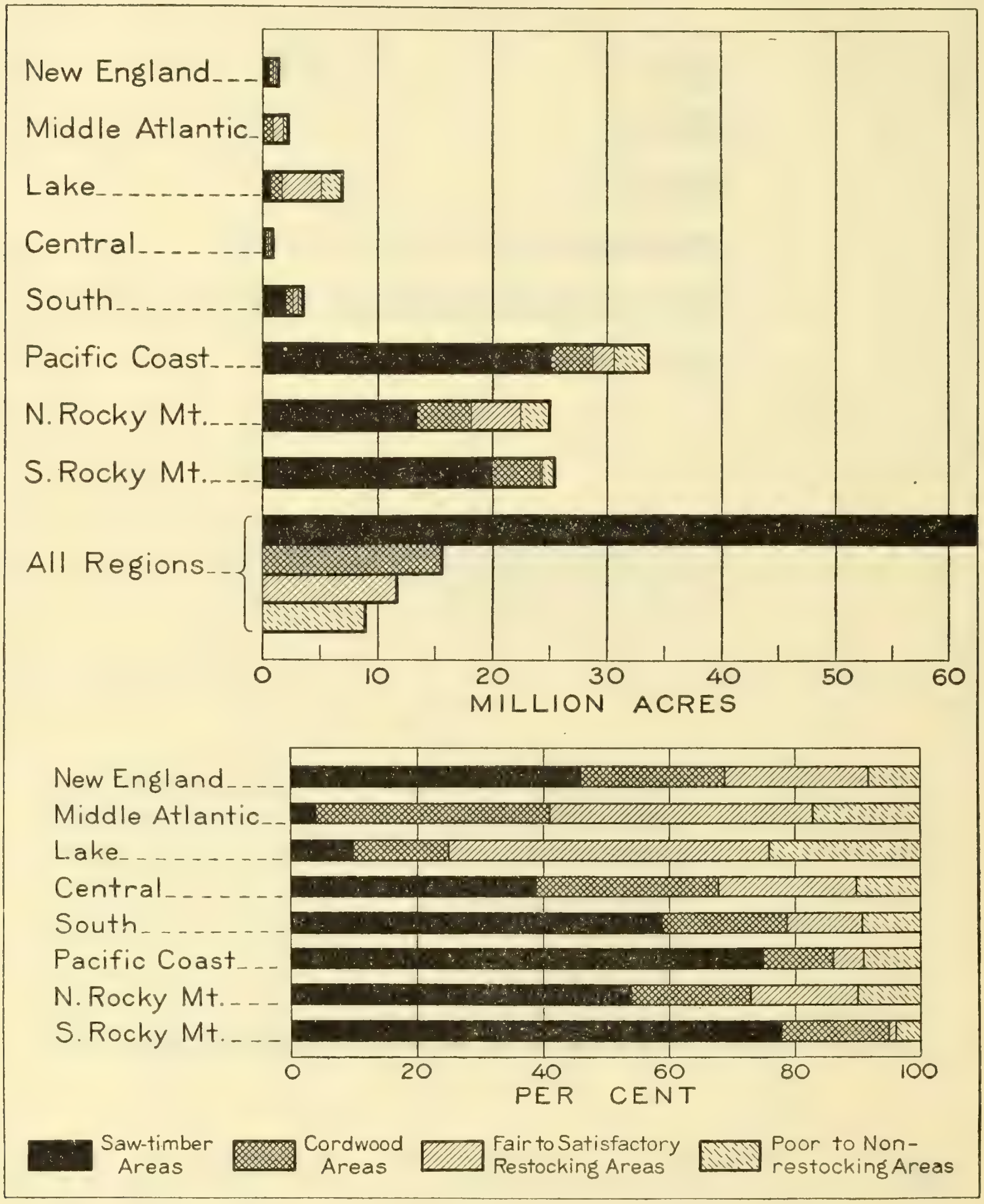

FIGURE 9.—Public (commercial) forest area by character of growth.

The fact that a large proportion of the farm woodlands occur as relatively small separate tracts tends to facilitate fire protection and to render them less exposed to epidemic insect and disease attacks.

Farm forest-land owners characteristically do not own or operate the sawmill or other manufacturing plants using their raw forest material. They are thus relieved of the additional worries and problems which go with such enterprises and they are relatively free to handle their forest lands with primary reference to the welfare of these lands or that of the farm enterprise.

In a general way, farm woodlands constitute an important factor in the economy of many farms. They are an integral part of the farm with no special overhead costs. Not only do they furnish fuel, fence posts, and other domestic products but they provide employment during off periods, and produce a cash crop which in many instances has proven a lifesaver. Within the naval-stores belt, farm woodlands no less than other forest lands with stands suitable for turpentine cupping have the added advantage of a revenue from the lease of timber for turpentining or from the sale of resin.

In the nature of the case a partial or selective method of cutting is adapted to farm woodland conditions. Probably without much conscious effort on the part of the owners, partly because of rough selection methods of cutting, and with less fire loss, farm woodlands—except where they are heavily grazed—are believed to be on the average in better growing condition than other privately owned lands. This class of land is capable of further development in systematic timber cropping through measures that are both simple and practicable.

Figure 8 reveals that the situation as to relative areas of age classes for farm woodlands also varies markedly by regions. In the South, the most important region of all, farm woodlands appear to have a higher proportion of poor to nonrestocking land than in any other important farm-woodland region. The Lake region, as under other ownership, has a rather high proportion of this land and a very high proportion of restocking area. The farm-woodland situation appears relatively favorable in the New England, Middle Atlantic, and Central regions.

Notwithstanding that there is much room for improvement in the condition of farm woodlands, particularly in some regions, it is believed that farm woodlands in general lend themselves readily to good forestry practice as an integral revenue-producing feature of the farm economy. Consequently, except as farms fall in the submarginal category, and are abandoned or revert to public ownership, the farm-woodland aspect of the Nation's forest situation does not constitute a particularly critical problem.

PUBLIC OWNERSHIP

Of the 99 million acres in public ownership, or about one fifth of our total commercial forest land, the bulk—88 million acres—is owned or managed by the Federal Government, 9½ million by the States, and more than a million by counties and municipalities. (Table 3 and fig. 10).

The West and East afford a pronounced contrast in the proportion of commercial forest land in public ownership, as shown in figure 9.

This, of course, is largely because the national forests, which contain 75 million acres of commercial forest land, were established in the West mainly by Presidential decrees applied to large areas of public domain, much of which contained virgin forests. The relatively small acreage of national forests in the East is the result of a movement originating in 1899. As the acreage in Federal ownership was negligible, the movement depended almost entirely upon purchase of land. About 4¾ million acres, largely cut-over lands, have been purchased to date, which combined with about 2½ million acres reserved from the public domain or acquired by exchange brings the total to over 7 million acres. The fact that the national forests in the East were developed in this way is one of the main reasons for the relatively high proportion of restocking and nonrestocking and the low proportion of saw-timber lands in public ownership in these regions. Effective consolidation of the existing units will require the further purchase of approximately 7½ million acres, but the situation requires many new units and a much greater area under public control.

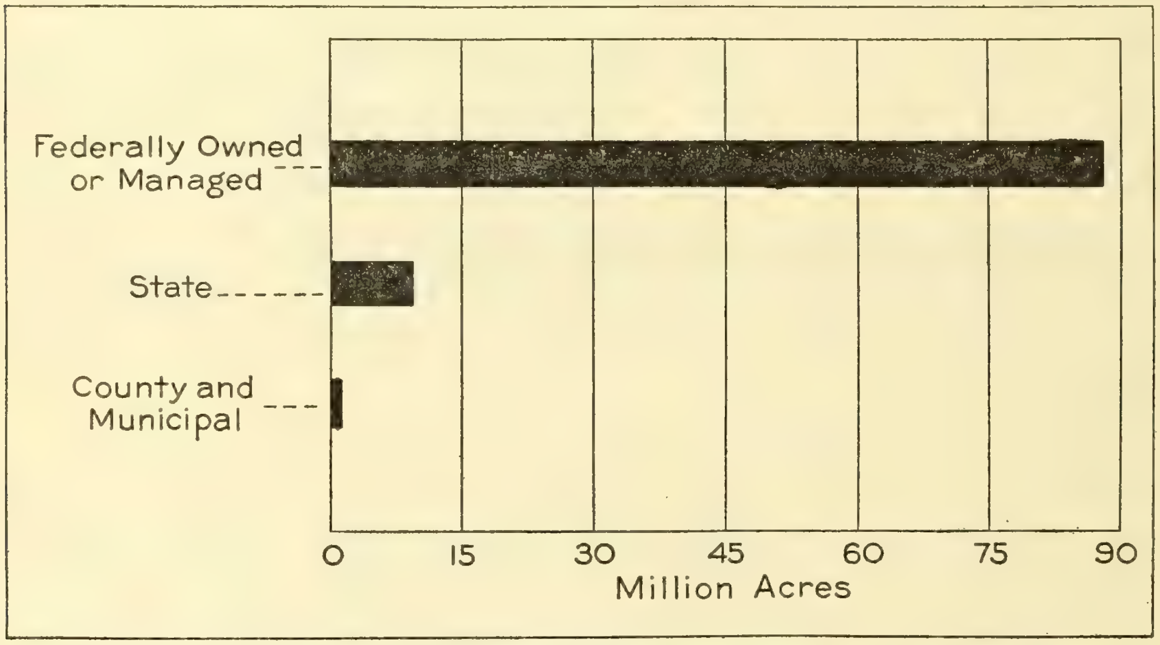

FIGURE 10.—Distribution of public ownership of commercial forest area of the United States.

Indian reservations include some 7 million acres of federally managed commercial forest land, and the public domain still contains most of the remaining 6 million acres federally owned. These, like the national forests, are mostly in the West.

Each forest region contains some State, county, or municipally owned forest land. It will be noted that of the 11 million acres of this land, more or less, nearly 4 million are in the Lake region.

Public ownership, broadly speaking, is the most stable type of forest-land ownership and in this respect, therefore, the most favorable for the continuous production of forest crops, or in other words for sustained yield. There is not the same incentive as in the case of the private owner for immediate as opposed to deferred returns. Long-time policies of management once adopted are not likely to be upset at the instance of a single individual. The indirect and collective forest benefits to the public at large may be more logically and effectively provided for in the management. Though by no means all of it, the bulk of the publicly owned forest lands are either now subject to conservative forestry practice, or are assured of such treatment when cutting shall take place. The main exception to this, of course, is the forest land which still remains in the public domain. Another important exception is the Oregon and California land grants upon which the timber under existing laws is being cut with little or no regard to maintaining the forest productivity of the land. (See section "Public Domain and Other Federal Forest Land.")

Public ownership, often accompanied by restrictions in private forest-land management, has long been accepted in many countries as the chief safeguard against the impairment of the sustained productivity and economic values of the forest resources of those countries. For the United States as a whole, the 20 percent publicly owned forest land is decidedly less than the proportion in the most of the older European countries. For example, in Germany 52 percent, in France 35 percent, in Sweden 24 percent, in Austria 28 percent, in Italy 35 percent, and in Switzerland 72 percent are publicly owned. The contrast, of course, is much greater for the eastern United States, where public forests include only 4 percent of the total commercial forest land.

Public forests are, generally speaking, a recognition of the difficulties experienced by private ownership in coping with the many perplexing problems involved in the practice of forestry. Obviously, unless greatly expanded, public ownership can not replace but rather can serve only to supplement timber production on privately owned forest lands. Publicly owned forest lands, in addition to their part in current and sustained yield production of timber products, serve as an assurance of timber supplies available in quantity to meet possible future emergencies.

It is not within the province of this section to outline a policy or program for the expansion of public forest lands from the standpoint of timber use but rather to present some of the outstanding aspects of the forest-land and land-ownership situation as it exists. It may be appropriate to say in passing, however, that the preparation of a public-ownership program will necessarily give consideration to the evident opportunity for large extension of public ownership in the eastern United States especially. However logical it might appear to rely upon public ownership as the main solution of our timber supply and other forest-land problems, it will be necessary to consider the practical difficulties, financial and otherwise, that would be faced in taking the bulk of the Nation's forest lands into public ownership. As a practical proposition, therefore, it would appear that a national forestry program should involve material extension of public ownership, by States, counties, and municipalities as well as by the Federal Government, but that it must also rely in important part upon the wise and conservative management of a large area in private ownership, both industrial and farm woodland.

THE PROTECTIVE FUNCTION OF FOREST LAND

Water is a basic resource of such widely varied necessity and usefulness in our individual and national life that its value can hardly be measured. Water for domestic and municipal use, navigation on our rivers and lakes, the operation of hydroelectric plants, and irrigation are outstanding examples. For these and many other purposes easily available water supplies in satisfactory amount and condition are limited, and our needs have been met thus far only with enormous effort and cost. Forested lands favorably influence the "water crop" in so many ways and to such an extent that the protective values inherent in these forest influences rival those of any other use of forest land.

Floods ordinarily cost us something like 40 million dollars annually, to say nothing of the expenditures for engineering-control works. Single floods sometimes amount to calamities. The Mississippi flood in 1927 is estimated to have cost some 300 million dollars. Forests will not prevent floods but adequate areas of forested land strategically located exercise such a favorable influence that no effective plan for flood control can fail to include forest lands as one essential element.

Forest cover delays the melting of the snows, the litter retards run-off, and the soil is very porous; these together induce soil absorption of water in the forest at a rate many times greater than for field or cultivated lands. The effect is measurably to retard and reduce flood peaks and, therefore, the destructiveness of floods.

The reduced and retarded run-off on forested land, the absorption of water by the soil, and the soil-holding effect of the tree roots combine to prevent the washing away or erosion of forest soils. Investigations have revealed that but a fraction of 1 percent as much soil per unit of area is eroded from forest land as from open-crop land. Surface erosion depletes the fertility of the land. In the aggregate, soil and fertility losses by erosion on cultivated and open land are tremendous. It has been estimated that 7 inches of the top soil of such lands in Illinois has been lost through erosion. The erosive effect of silt-laden streams is much greater than where the water is clear; the silt is deposited in reservoirs, clogs up hydroelectric plants and engineering works, forms sand bars and otherwise interferes with navigation, and prevents the use of the water for domestic and certain industrial purposes. The beneficial effects of forested lands strategically located on river watersheds in reducing erosion and its resultant ills are therefore diverse and highly important.

The benefits of forest cover in keeping water in springs, streams, and reservoirs clear and pure for domestic use are universally recognized. An adequate supply of domestic water for our urban centers has become a vast and expensive problem. San Francisco is securing water from the Sierras 200 miles away; Los Angeles across 200 miles of desert and mountain from Owens River; New York City is drawing its supply from the Catskills by costly conduit and is reported to be looking for additional sources at much greater distance. The importance to navigation of clear water and stabilized flow and to the enormous hydroelectric plants, are too obvious to require description. The importance of clear and permanent streams to fish life and to recreation generally are perhaps not so widely appreciated but are none the less important.

The shelter against strong drying winds afforded by forests to homes, crops, and livestock is very important in some localities and constitutes a definite protective function of forest land. This function also includes protection against shifting sands and the formation and movement of sand dunes.

The protective value of forested lands is largely independent of the exact type of cover though not of its condition. The dense spruce forests of high altitudes and northerly latitudes, the hardwood forests of the Appalachians, the mixed forests of the Piedmont region, the open scrubby piñon of the West, the chaparral of the Southwest, and the brushy windbreak stands all possess high protective values. Therefore, the protection value of forest lands is somewhat independent of their value for timber production. Some of the forest lands most valuable for protection are not classed as commercial.

In the neighborhood of four-fifths of the total 615 million acres of forest land may be classed as valuable for protection. The exceptions are swamp lands and bottom lands at the mouths of rivers, and lands having such sandy or gravelly soil that the presence or absence of forests would have practically no effect on the behavior of streams or the process of erosion.

The protection-forest lands controlling run-off and erosion are on the whole well located on the headwaters of important streams. From the point of view of protection, however, there is considerable need for additional areas of forested land on many relatively small streams, as well as in strategic locations on the watersheds of several important streams of which the Ohio, Missouri, Hudson, Delaware, and Sacramento are examples.

With some exceptions, such as municipal watersheds, other forest uses need not be excluded for the sake of the protective function. Timber growing and utilization under systems of practices which will provide for maintenance and protection of a forest cover in conformity with the dictates of good timber management would, generally speaking, prevent serious impairment of forest influences. Under existing practices, however, especially on large areas of both public and private land, the situation is far from satisfactory. From the standpoint of protection, the forest should not be cut so severely that the ground is unnecessarily exposed. Continued absence of cover will hasten run-off and induce erosion. In many cases partial cutting that would fully maintain the forest influences would be financially advantageous from the standpoint of timber use.

The forest should be amply protected against fire, especially following cutting. By destruction of the litter, and in other ways, fire greatly aggravates deterioration in forest influences. The forest land should not be grazed so heavily as to prevent restocking, or to destroy ground cover and leaf litter. Such grazing leads to increased erosion and floods.

The unsatisfactory protection condition on many private tracts of forest land, the need for additional strategically located areas of public forest, and the present very low percentage, 4 percent, of commercial forest land in public ownership in the East—all indicate the advisability of giving consideration to the protective function of forest land, as well as to timber use and other needs, in formulating a program of public acquisition in the East.

THE USE OF FOREST LAND FOR RECREATION

Recreation is by far the most direct contact which most Americans have with the forest. The growing and utilization of timber and the protection of watersheds are at best theoretical considerations with the majority of people who have directly experienced the forests' value for relaxation, for play, and for aesthetic enjoyment.

The available figures for recreational use of public lands during 1931 indicate that there were more than 3 million visitors to national parks, about 32 million to national forests, and probably 50 million to State parks and forests. While there is a great deal of duplication among the visitors thus recorded, it is patent that a very material proportion of our population made some use of Federal and State forest lands for recreation. The number who had recourse to municipal, county, and private forests can only be conjectured, but it must have been very large. Recreation, then, is a tremendously important forest-land use today, and every indication points to a great increase in its volume in the future.

The forms which forest recreation takes are of wide variety. The largest fraction of the recreationists only pass through the forests in their autos. A considerable group, however, establishes residences in the forest for some portion of the year. Hunting and fishing is one of the most popular forms of forest recreation, it being estimated that 13 million people indulged in those sports during 1929. The number of people who go hiking, riding, or canoeing every year runs well into the millions. Most of these merely go on journeys of a single day or less, but there are increasing hundreds of thousands who are going on at least overnight trips into the forest, some of them staying away from civilization for weeks at a time.

The recreational needs of these vast numbers of people may be satisfied in many cases by lands which are being used for timber production, especially if methods of cutting and safeguards for restocking and protection in keeping with the dictates of good timber use are exercised. Recreational values will usually be temporarily suspended during logging and often during the periods required for forest regeneration. Otherwise, it may be said that, broadly speaking, all forested land under sustained-yield management is valuable for recreation.

There will be certain areas, however, which have such exceptional recreational value that they will need to be withdrawn from commercial timber use. These will include areas of superlative scenic value, samples of primeval forest conditions, some wilderness areas, wooded strips along the main traveled highways, camp grounds, and hotel and summer-home sites. Included also will be some 6 million acres of forest land required to satisfy the needs of those who wish to purchase forest land solely for home sites or other recreational purposes.

Further, a certain amount of commercial forest land will need to be reserved in the neighborhood of population centers where the intensive recreational use promises so to congest the available woods that almost no timberland can be spared for even the few years required by most forest types to recover a semblance of scenic value under the best silvicultural practice.

Table 4 indicates very roughly by regions the approximate acreage which it may be desirable to reserve for recreational use. Of this, approximately one tenth will be permanently withdrawn in private ownership. Reservation of the remainder, for the most part in public ownership, does not necessarily mean that no timber will ever be cut on any of this area; but rather that for the present its recreational value seems so high that no commercial logging operations should be planned, even though light selection cuttings may be permitted on special tracts.

In the West, it will be observed, a large share of the additional recreational withdrawals may be confined to lands where timber production probably would have no practical significance for many years. In the East, where there is relatively little inaccessible land, the recreational withdrawals will have to come from lands which would otherwise play a part in timber use. Recreational needs should, therefore, be an important consideration in formulating a program for public acquisition of forest land in the East.

TABLE 4.—*Estimated area of present commercial forest land that may well be reserved for recreation*

Region	Total area	Already withdrawn	Additional withdrawal	Withdrawals of low production value
	Acres	*Acres*	*Acres*	*Acres*
New England	6, 000, 000	100, 000	5, 900, 000	
Middle Atlantic	8, 400, 000	2, 500, 000	5, 900, 000	
Lake	4, 000, 000	2, 600, 000	1, 400, 000	
Central	2, 900, 000	500, 000	2, 400, 000	
South	3, 500, 000	600, 000	2, 900, 000	400, 000
Pacific Coast	9, 500, 000	1, 800, 000	7, 700, 000	5, 900, 000
North Rocky Mountain	6, 200, 000	400, 000	5, 800, 000	5, 100, 000
South Rocky Mountain	4, 500, 000	2, 500, 000	2, 000, 000	1, 600, 000
Total	45, 000, 000	11, 000, 000	34, 000, 000	13, 000, 000

USE OF FOREST LAND FOR GAME

The social and economic values contained in wild life are of far reaching importance in the multiple-use management of forested areas. Forest lands in one form or another furnish the environmental conditions in whole or in part for all classes of game, fur bearers, and other wild life except that which prefers open country and unwooded marshland. Direct economic values attributable to game include those of food and fur, and income from sale of hunting and fishing licenses. Indirect values include the market afforded by hunting and fishing to manufacturers of arms, ammunition, fishing tackle, clothing and other outdoor equipment; expenditures of sportsmen for board, transportation, guide service, and sundry supplies; annual expenditures of sportsmen and clubs for hunting and fishing privileges in private lands; and benefit of wild life, chiefly birds, as destroyers of insects preying on agricultural crops. These various values total well over 1 billion dollars per annum according to W. L. McAtee, of the United States Biological Survey, who has made an intensive study of the subject. For the State of New York, for example, estimated expenditures of hunters and fishermen were more than 14 million dollars in 1931.

Revenues from a game crop can be secured by proper management measures. Present-day problems of land management and awakening recognition of wild-life values, are turning the attention of land managers and economists to the potentialities of game as a forest land resource. Experience tends to demonstrate that game values are an important source of income, particularly during long periods needed for rehabilitation of depleted forest areas.

Social values of forest game life are far-reaching. Game and fish are closely associated with recreation. Additional leisure for the average man through shorter hours and less days of work will add tremendously to those who seek the "out-of-doors" form of recreation. Hunting and fishing will attract large numbers of these folk. Wild life in general affords enjoyment, the opportunity for building health and character, and for increasing scientific knowledge. In the report of the Special Committee of the United States Senate on Conservation of Wild Life Resources, it is conservatively estimated that there is a 400 percent increase during the decade ending with 1930 in the number of people who enjoyed the pastimes of hunting and fishing.

Most, if not all, of the forest land of the United States is susceptible to the production of one or more species of wild life having social or economic values.

THE RANGE RESOURCE OF FOREST LANDS

The forage produced by herbaceous and shrubby plants under the trees and in openings in the forest is one of the major resources of forest lands. More than half the forest land of the country is grazed by domestic livestock. Feed furnished, for periods of 3 months in the higher mountains or the full year on some low elevation forest ranges, amounts to about 12 percent of all pasturage of the United States. Grazing furnishes a current return to many timberland owners, it aids in fire protection, and helps to make forests accessible with roads and trails. This forest land use is of two general types: The range type, which predominates in the West and South and to some extent in the Appalachians, and the woodland pasture type typical of the central farm belt.

The extensive forest lands of the West, largely occupying the mountain areas, furnish a considerable percentage of the summer feed for the beef cattle and sheep of the Rocky Mountain and Pacific Coast States. The nutritious forage, cool climate, and shade of forest lands all combine to facilitate growth of calves, lambs, and wool.

Within or near almost every western forest-range area there are agricultural communities whose prosperity is mainly dependent upon the production of livestock. Many of the farms within these communities are small and far from markets. Without the aid of complementary forest land range, however, most of such farms could not long exist. These forest ranges, with their ability to produce high quality beef and mutton at a nominal cost for forage, are indispensable in offsetting the more expensive production and feeding of cultivated crops. More than 4½ million acres of improved farm land and 22 million acres of private or leased grazing land, for example, are used in connection with the 83 million acres of national-forest land now grazed. Without forest ranges a large proportion of associated farm lands and the community life dependent upon them would never have been developed so satisfactorily.

In the South there are already over 100 million acres of cut-over pine lands alone. After logging operations, grass and other herbs and shrubs become abundant and often form a nearly complete cover. These native ranges, ordinarily unfenced, furnish good grazing from early spring until July or August, and for that period grazing capacity is relatively high. After October, the native grasses are coarse and wiry and the forage for grazing inferior.

Although forest lands are usually grazed by the livestock of local residents, these residents seldom own them or lease the land from the large timberland owners. Characteristically, the land has been burned annually, especially since turpentine operations began. The turpentine operator has burned in winter to safeguard the trees he is operating against accidental summer fires which cause great damage. The native cattle owner burns in the belief that he will improve the forage. Such burning on cut-over lands may damage timber reproduction or even kill it, as in the case of slash pine. It is also apt to slow down the growth of the larger trees.

In the Central States region, characteristic of the woodland pasture type of range, about a half of the commercial forest land is farm woodland, of which over a half is grazed. Outside of the "blue grass" regions of Kentucky and Tennessee where the forest has been intentionally opened up to provide better pasture, farm woodlands are grazed with a view to producing such supplemental revenue as can be obtained. In the four Corn Belt States—Ohio, Indiana, Illinois, and Iowa—over three fourths of the timbered area is in farm woodlands, and nearly three fourths of this area is grazed. In this region the forested lands are used more for shade, shelter, and incidental roughage than for the primary purpose of forage production.

Under sound forestry practice grazing may, generally speaking, be exercised in coordination and harmony with the other major forest-land uses; in some types, however, grazing may have to be temporarily suspended during forest regeneration. At all times it should be practiced conservatively, not only to avoid impairing forest-protection values, but also to avoid the depletion of the forage resource itself.

On certain municipal or other intensive domestic water-supply areas grazing has been excluded altogether. Where certain types of wild life are the object of management—as, for example, deer—it may be desirable to restrict or eliminate grazing. On certain areas heavily used by recreationists all the forage may be required for the grazing of pack stock.

Probably the most extensive and noteworthy example in the world of regulated grazing use coordinated with the other forest-land uses is to be found on the national forests. Efforts, effective on the whole, have been made to obtain efficient use of the forage, to prevent depletion, and to rehabilitate ranges previously depleted. Forage use is adjusted to meet the requirements for timber use, protection, recreation, and game. In varying degree similar coordination of grazing with other uses is secured on other publicly owned or managed lands.

Such control and coordination are not secured on the public domain forest lands nor as a rule upon privately owned forest range in the West. Consequently the forage resources of these lands are usually depleted and at least the protective functions rendered less effective. In much of the East the forage resource is less susceptible to overgrazing, but in many woodland pastures within the hardwood types constant grazing has been responsible for the nonestablishment of young forest growth, and the progressive deterioration of the forest stand.

SUMMARY OF FOREST LAND SITUATION

PRESENT AREAS

In all, 615 million acres, or one third of the continental United States, is forest land. This forest land is a basic resource, adapted to five major uses, each of which constitutes a large and essential phase of our economic and social life. With some important exceptions, as in cases where tracts of forest land are designed to serve a highly specialized purpose, these uses need not be mutually exclusive. On the contrary, forest land characteristically, insofar as economic circumstances make it feasible, may efficiently serve several or all uses at one time, and constitutes a multiple-use resource of vast proportions and importance.

These five major uses or functions of forest land may be summarized as follows:

TIMBER USE

Wood in various physical and chemical forms has long been an essential commodity to mankind. When this country was settled by the white man it was providentially endowed with a vast store of virgin timber—a natural supply which has furnished us the greater portion of the wood for commercial use. These virgin supplies are substantially cut out in the eastern United States. The remaining reservoir of virgin timber is in the West. It is not unlimited. To continue to supply the needs of the country for timber and wood products, forest land must be used to grow successive crops of timber in somewhat the same manner that agricultural lands are used to grow agricultural crops.

Of the total of 615 million acres of forest land, about 495 million acres of what in this report is called commercial forest land is considered to be capable of growing a volume and quality of timber that under recent or reasonably conceivable future conditions may be economically available for consumption. This commercial forest land, which does not include productive areas withdrawn for one reason or another from commercial exploitation, occupies about one fourth of the area of the United States. It exceeds by a wide margin the area of land actually in agricultural crops.

The following tabulation shows nationally a broad classification of this commercial forest area by present condition of forest cover:

	Acres
Old growth (mature) saw timber	99, 000, 000
Second growth (immature) saw timber	90, 000, 000
Cordwood areas (characterized by trees of cordwood size)	121, 000, 000
Logged or burned:	
Fair to satisfactory restocking	102, 000, 000
Poor to nonrestocking	83, 000, 000
Total for the continental United States (exclusive of Alaska)	495, 000, 000

The whole of this gross area is not now nor will it be likely to be effective producing forest-land capital for a great many years. Considerable areas are economically inaccessible under present conditions. Much of the 83 million acres described as poor to nonrestocking will have to be planted before it can produce a merchantable timber crop.

Some future withdrawals from timber use will be desirable for special purposes. It is roughly estimated that 34 million acres additional should be thus withdrawn from the commercial category for recreational purposes. On the other hand, the area of commercial forest land available for timber use may be increased by reforesting areas of abandoned or other agricultural lands which are deemed no longer essential for agriculture. This aspect of the land situation is referred to later in this summary, and in more detail in the section, "Agricultural Land Available for Forestry."

From the standpoint of timber use, the character of ownership of forest land is important. The following tabulation summarizes the distribution of the present acreage of commercial forest land for the three broad classes of ownership:

	Acres
Publicly owned or managed forest land	99, 000, 000
Industrial forest land	269, 000, 000
Farm woodlands	127, 000, 000
Total	495, 000, 000

The previous discussion emphasizes the fact that the publicly owned land is nearly all located in the West while the farm woodlands are mostly in the East.

PROTECTIVE FUNCTION

It is estimated that on approximately four fifths of the forest land of the country forest influences have a definite protective effect expressed in the regulation of stream flow, the maintenance of water supply, the prevention of erosion, and the amelioration of destructive winds and other severe climatic conditions.

However, relatively little of this area should be withheld from timber or other use for the sake of protection. Among the few exceptional tracts are some protecting municipal watersheds. In general, when managed under practices which are satisfactory from the timber use standpoint, forest land will sufficiently fulfill its protective and other functions simultaneously. The fact is brought out in this report, however, that under present conditions large areas of forest land exist which, because of present forest cover, are not satisfactory protection forests.

RECREATIONAL USE

Recreation, broadly defined as the use of the forest for play, relaxation, aesthetic enjoyment, and inspiration, is a tremendously important and rapidly growing forest-land use. In general all forest land, if it has not been severely damaged by fire and logging, is potentially adapted to some form of recreational use. Some forest land has such high recreational value, however, that it should be set aside entirely from commercial development. Already 11 million acres of forest land, of which the national parks are the outstanding example, are withdrawn from commercial timber use on account of recreational values. It is estimated in this report that eventually an additional 34 million acres should be withdrawn from the commercial forest land category for recreational purposes. A considerable portion of this will fall in the least accessible zones of commercial forest land and therefore the conflict with timber use needs will not be so great as might be implied by the figures alone.

GAME AND WILD LIFE

The great bulk of forest land is capable of producing game and wild life. However, the condition of the forest cover is an important factor in the extent and character of the food supply. Cutting operations usually lead to increased growth of shrubs and herbage, thus providing a greater abundance and variety of food than is to be found in dense forests. In general, the protection of forest land from fire, and the application of desirable silvicultural measures in the development and use of the timber resource, contribute to the welfare of wild life. The character of the ownership of the land is also an important factor as it affects access to the land by the public, and the possibilities for effective correlation of wild life and land management.

RANGE USE

This use is exercised over more than half the forest land in the United States. As a rule, grazing may be harmonized satisfactorily with other major forest-land uses. In some instances it should be temporarily suspended during forest regeneration. At all times it should be exercised conservatively to guard against damage to the forest-protection values and against depletion of the forage resource itself. On certain intensive protection areas it should probably be excluded altogether.

Forest-range conditions are far from uniformly satisfactory. On the unregulated public as well as much of the privately owned forest land of the West, and on much of the forested pasture land of the East, grazing has been exercised with little regard for the forage resource itself or for the values of the forest land for other purposes.

Any one of these major uses is essential to national welfare. In the aggregate they give some conception of the great importance of forest land. It is of the utmost importance that forest land should serve these uses effectively and also that these uses be maintained, developed, and harmonized in order that no considerable part of so fruitful a resource need lie idle and unproductive.

The practice of forestry in the broad sense then means much more than the mere production of timber. It includes the management of forest lands, usually with timber production as one of the major uses, but not an exclusive one. It means the management of forest lands to secure a maximum of coordination and combined effectiveness in all these uses.

AGRICULTURAL-LAND ABANDONMENT

The forest-land situation is by no means static. The process of converting forest land to farm land is still going on, particularly in the western regions where the removal of virgin timber from a land of favorable soil and climate invites settlement. It is roughly estimated that some 2 million acres should be deducted from the commercial forest-land acreage to account for such present and prospective conversion.

While this process is continuing on a small scale in the West the opposite process—agricultural-land abandonment—is taking place on a major scale in the regions of the Eastern United States. The future progress and the net effects of these transitions are not susceptible of refined determination. They are the result of complex and changing economic and social conditions. The best information now available appears to indicate that so far as the relation between forest and agricultural use is concerned, the national trend is likely to continue from agricultural to forest use for a good many years.

The section, "Agricultural Land Available for Forestry," discusses the relation between agriculture and forest use and the resulting trends in considerable detail. It is sufficient here to note that about 52 million acres of land once or still considered as agricultural, and not included in the present forest-land acreages previously presented in this report, is no longer needed for agriculture and may be considered as available for forest use. This acreage is made up as follows:

	Acres
Abandoned agricultural land	26, 000, 000
One half of the 1930 Bureau of the Census estimate of the idle and fallow agriculture land	11, 000, 000
One half of the unforested and unplowable pasture land	15, 000, 000
Total	52, 000, 000

This 52 million acres, occurring as it does in the East and within the territories once cleared for agriculture, may, for practical purposes, be considered as commercial forest land, if and when forested. Because of its location, it would be very valuable for protection, for which use some minor areas might need to be set aside exclusively. Generally speaking, its site quality would make it very desirable for timber production, probably somewhat more so than the average cut-over and nonrestocking land now included in the commercial forest-land category.

A further possible addition to forest-land acreage is found in certain areas of treeless prairies in the Central States which never have been forested but which are considered to be physically suited to afforestation. A figure of 3 million acres will be ample to provide for this.

PROSPECTIVE AREA AVAILABLE FOR TIMBER PRODUCTION

The net effects of such estimated amounts upon present or potential commercial forest-land acreage may be summarized as follows:

	Acres
Present acreage of commercial forest land	495, 000, 000
Present acreage of agricultural land abandoned or otherwise available for forestation	52, 000, 000
Acreage of treeless prairies available for afforestation	3, 000, 000
Gross acreage of potential commercial forest land	550, 000, 000
Area of present commercial forest land to be withdrawn for recreation	34, 000, 000
Deduction for conversion from forest to agriculture in the West	2, 000, 000
Miscellaneous deductions for protection, etc	5, 000, 000
Gross acreage of prospective withdrawals	41, 000, 000
Net acreage of potential commercial forest land	509, 000, 000

An additional 25 to 30 million acres of agricultural land in the eastern United States may become available for afforestation by 1950 according to an estimate contained in the section, Agricultural Land Available for Forestry. Because of its location and character this area, like the 52 million acres just considered, may be considered as suitable for commercial timber production and for protection purposes.

Thus, of gross forest-land acreage there appears to be ample, according to the discussion headed Present and Potential Timber Resources, if it is wisely managed, to meet the ultimate timber-supply needs of the country and at the same time to serve adequately the other major uses. To make these potentialities realities will require constructive programs which will provide for improvement in many phases of forest-land use.

THE AGRICULTURAL LAND AVAILABLE FOR FORESTRY

By C. I. Hendrickson, Senior Agricultural Economist, Bureau of Agricultural Economics

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AGRICULTURAL LAND ABANDONMENT IN THE ORIGINALLY FORESTED REGIONS EAST OF THE GREAT PLAINS[1]

The term "agricultural land" will be used here to refer to the land used for the production of crops and livestock, including the necessary farmsteads, lanes, and farm roads, but excluding the woodland or forested area devoted to timber production. "Abandoned agricultural land" refers to land which has definitely gone out of the production of crops or livestock and has reverted to some less intensive use or is being allowed to lie idle. Land which has gone out of agriculture and into some more intensive use, such as residential or other urban use, is not considered as abandoned agricultural land.

These terms are used instead of the terms "farm land", "abandoned farms", or "farm abandonment" which are often used without any strict definition of their meaning. "Farm land" usually includes the woodland within the boundaries of farms. The abandonment of a farm effects no change in the major use of the woodland and to include the woodland, as is done when the total farm land is used, exaggerates the amount of agricultural abandonment.

The term "abandoned farms" is most frequently used to refer to farms on which agricultural operations are no longer being conducted. In some instances it is used to refer to farms which have reverted to the State or other political unit for the nonpayment of taxes; such farms may or may not be operated farms. The extent of agricultural abandonment would be underestimated if only abandoned farms, i. e., those on which agricultural operations are no longer being conducted, were considered. There is, in addition to wholly abandoned farms, land in operated farms which has been abandoned for agricultural use.

The abandonment of the agricultural land in specific farm units is usually a gradual process. The stages vary from tract to tract. Frequently, especially in the Northeastern and North Central States, the successive stages are as follows: (1) Abandoned for cultivated crops and used as a permanent hay meadow; (2) abandoned for hay and used as permanent pasture; (3) gradual encroachment of brush on the permanent pasture; (4) the gradual seeding and growth of trees and return to forest. In the South livestock is relatively less important and the use of the land for hay and pasture is more frequently omitted. There are instances of the omission of the brush stage where the trees develop with very little growth of herbaceous plants and shrubs. Changing economic conditions may cause land in some stage of abandonment to be placed again in cultivation. Land which has been exhausted by cropping may be abandoned and allowed to complete the process and grow into forest, then be cleared, and again put into cultivation. In such cases there is developed a cycle of land use. Prior to the introduction of fertilizers this cycle of land use was more common in the South. There are areas where this cycle of land use is still going on.

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[1] This discussion of agricultural abandonment is limited to the originally forested regions of the United States east of the Great Plains. The prairie counties of Illinois, Iowa, Minnesota, Missouri, Arkansas, Louisiana, Oklahoma, and Texas are not included. Most of the abandonment of agricultural land has occurred in the originally forested regions east of the Mississippi River, and here abandonment is most significant with reference to reforestation.

Farm abandonment is the result of a complex of forces. Certain of these forces are more important in some areas than in others. Seldom, if ever, do these forces operate singly. In one area one force may appear to be, on superficial examination, the sole cause of abandonment, when in reality other causes have cooperated to produce the result. Land has been operated so lacking in fertility, so rough in topography, or so stony, that it has not been profitable except under especially favorable conditions. After more or less effort has been expended the land has been abandoned. Other land may have been profitable or reasonably profitable when first cultivated but its fertility may have been depleted through continued cropping without restoring the fertility removed or—a much more important factor—through erosion. Erosion has been particularly important in certain areas in bringing about abandonment of land for agricultural production.

In addition to these physical factors economic factors have been important. Improvements in transportation made possible the opening up of the land west of the Alleghenies and the settlers there were able to ship their products and sell them at prices below what the eastern farmer could afford to take. At first it was the less perishable cereals, wool, live cattle and hogs; then with the development of refrigeration, fresh meat and dairy products, fruit and truck crops came from areas where climate, soil, and other natural conditions favored their production. The development of machinery has also been a most important factor in effecting the abandonment of rough stony land in particular. While machinery was adapted to the more level land such as the prairies of the Corn Belt and the Great Plains region and enabled the farmers there to produce at a lower cost, many areas of rough topography were not adapted to these labor saving methods and hence could not compete with the farmer on the more level land. These improvements in transportation and machinery have led to the abandonment of much land which lacked natural advantages but which had been put into cultivation prior to these developments.

At the same time that this competition from the more fertile, level land was lowering the income of the farmers in the less fertile, rougher land the development of commerce and manufactures offered opportunities which attracted people from the farms to the cities. Where these opportunities have been lacking, as in the southern Appalachians, much land is in cultivation which is rougher and less fertile than land in other areas which has been abandoned. Not large in the aggregate, but important in some areas as a cause for abandonment has been the loss of an industry which afforded a market for the agriculture of a particular area. A corollary factor has been the increased taxes made necessary by the lessened tax base resulting from the loss of the industry. The cutting of timber and the removal of the timber industry in certain areas have resulted in loss of local markets for farm products and increased taxes on the farms which became a contributing cause to agricultural abandonment. Abandonment, in turn, may lead to further abandonment by reason of the higher taxes on the remaining farms or lessened government revenue and deterioration in community life. On the other hand, the leadership of energetic and resourceful individuals in a community may sometimes retard or even prevent abandonment.

No survey of farm or agricultural land abandonment has been made covering any large area of the United States. There have been a number of limited surveys of small areas in connection with land use studies, but they have not been extensive enough to provide a satisfactory base for general estimates. They have been conducted at different times and by different agencies, and therefore the results are not directly comparable. It is necessary to judge the extent of agricultural abandonment from the decrease in land used for agricultural purposes as calculated from the Federal censuses.

The total area of land used for agricultural purposes continued to increase in the originally forested regions east of the Great Plains until 1920. The Federal census of 1920 reported 279,000,000 acres of agricultural land in these regions.[2] Approximately 60 percent of this was crop land, about 25 percent was other improved land, and 15 percent was what is designated as unimproved land. The improved land not in crops was largely plowable pasture and the unimproved land was mostly pasture which could not be plowed because it is too hilly or too wet, or because of brush, stumps, or rocks. Considering these forest regions as a whole, the first decline in the total area of land used for agriculture occurred during the decade 1920 to 1930. The area of agricultural land declined by 14,000,000 acres, or 5 percent (see table 2), and the land in harvested crops by about 15,000,000 acres, or 9 per cent (see table 3). There was less agricultural land in these eastern forest regions in 1930 than in 1910, and about the same area of crop land as in 1900. The decrease in crops from 1920 was relatively greater than the decrease in agricultural land because some of the crop land went into pasture.

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[2] Agricultural land as used in this report is the total area in farms less the area in woodland, as reported by the Bureau of the Census. This item contains a small amount of waste or idle land not in woods which cannot be separated from the land used for crop and livestock production. The extent of this item is not sufficient to affect the conclusions derived from the data.

TABLE 1.—*All land in farms, by regions, originally forested counties* [1] *east of Great Plains, 1880–1930*

Region	Year					
	1880	1890	1900	1910	1920	1930
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	21,484	19,756	20,549	19,715	16,991	14,283
Middle Atlantic	52,712	48,996	51,096	49,287	46,275	40,322
Lake	32,381	35,678	43,688	47,508	50,165	48,182
Central	119,680	119,823	126,276	125,641	123,482	114,878
South	153,346	157,889	170,208	178,576	174,107	158,509
Total	379,603	382,142	411,817	420,727	411,020	376,174

[1] Prairie counties in Illinois, Iowa, Minnesota, Missouri, Arkansas, Louisiana, Oklahoma, and Texas not included.

TABLE 2.—*Agricultural land,*[1] *by regions, originally forested counties east of Great Plains, 1880, 1910–30*

Region	Year					
	1880	1890	1900	1910	1920	1930
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	14,168			11,862	9,970	7,883
Middle Atlantic	39,085			38,311	36,066	31,629
Lake	22,084			36,670	38,639	36,074
Central	70,865			91,556	92,486	88,937
South	65,635			96,448	102,256	101,164
Total	211,837			274,847	279,417	265,687

[1] All land in farms less woodland in farms. The census of 1890 and 1900 collected no information on the woodland in farms.

TABLE 3.—*Approximate acreage of crops harvested by regions, originally forested counties east of Great Plains, 1879–1929* [1]

Region	Year					
	1879	1889	1899	1909	1919	1929
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	5,929	5,604	5,194	4,967	4,561	3,677
Middle Atlantic	21,829	22,274	22,142	20,845	20,718	17,198
Lake	12,556	15,463	18,789	19,965	22,893	21,877
Central	40,334	45,370	50,467	49,902	52,943	45,258
South	39,177	45,031	53,040	58,380	66,039	63,956
Total	119,825	133,742	149,632	154,059	167,154	151,966

[1] The schedules used and the crops included were not the same for each census, thus data given are not always strictly comparable. The last census, 1930, was somewhat more inclusive than the earlier ones.

TABLE 4.—*Changes in agricultural land, by regions, originally forested counties east of Great Plains, 1910–30*

Region	Changes in agricultural land [1]			
	1910–20		1920–30	
	Gross increase	Gross decrease	Gross increase	Gross decrease
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	56	1, 948	5	2, 092
Middle Atlantic	61	2, 306	-- --------	4, 437
Lake	2, 644	675	448	3, 013
Central	2, 685	1, 755	1, 382	4, 931
South	9, 673	3, 865	5, 367	6, 459
Total	15, 119	10, 549	7, 202	20, 932

[1] Gross increase is total of increases in counties having increases and gross decrease is total of decreases in counties having decreases during the decade.

Although the decade 1920–30 was the first to show a widespread decline in the total agricultural land or in total crop land, land abandonment has been going on for many years. In some counties in the northeast, considerable land was abandoned 50 years ago, but these decreases were more than counterbalanced by increases in counties elsewhere in this region. Even during the decade 1910–1920, when there was a large increase stimulated by war prices, land was abandoned in many counties. The counter-movement persisted locally even during the last decade, 1920–30, many counties showing an increase in agricultural land while the total for these forest regions as a whole declined.

The net increase in agricultural land from 1910 to 1920 was 4,500,000 acres. There was a decline of 10,500,000 acres in certain counties, which was more than offset by an increase of 15,000,000 acres in other counties of the region. The net decline in agricultural land between 1920 and 1930 was 14,000,000 acres, the net resultant of a decrease of 21,000,000 acres in a majority of the counties, offset in part by an increase of 7,000,000 acres in other counties. (See table 4.) The increases occurred mostly in the western part of this originally forested region, while the counties reporting a decline were scattered in all States of the region. In the eastern States the decline was almost universal. Agricultural abandonment, like agricultural development, has proceeded from east to west. The earliest and the greatest amount of abandonment has taken place in New England and New York. Relatively less abandonment has taken place in the States to the west and south, and it has occurred at a later date. (See fig. 1.)

Not all of the land which has gone out of agricultural use is available for reforestation. Some of it has already grown up to trees and is included in the forest area, another portion has gone into residential,[3] recreational, and other uses. Probably most of the land abandoned prior to 1900 has become forest. Relatively less of the land abandoned in each succeeding decade since 1900 is now in forest. Not even all of the 31,000,000 acres (see table 4) which has gone out of use for crop and livestock production in the past two decades is still available for reforestation. It is probable that a substantial part of the 21,000,000 acres which has gone out of agricultural use since 1920 is available for reforestation and a portion of the 10,500,000 acres which went out of use for crop and pasture in the decade 1910 to 1920 is available. The rate at which these acreages will grow up naturally to trees will depend upon a number of factors, including the quality of the land, the number and species of seed trees, and protection from fire and other injury.

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[3] Not all of the land which has gone out of agricultural use as calculated from the Census reports has actually gone out of agricultural production, since some of that used for residential purposes has attached to it land used for gardens, etc. Figures showing the actual amount of land used for agricultural production in units smaller than those considered as farms by the Census are not available, but the amount probably is comparatively small in the aggregate.

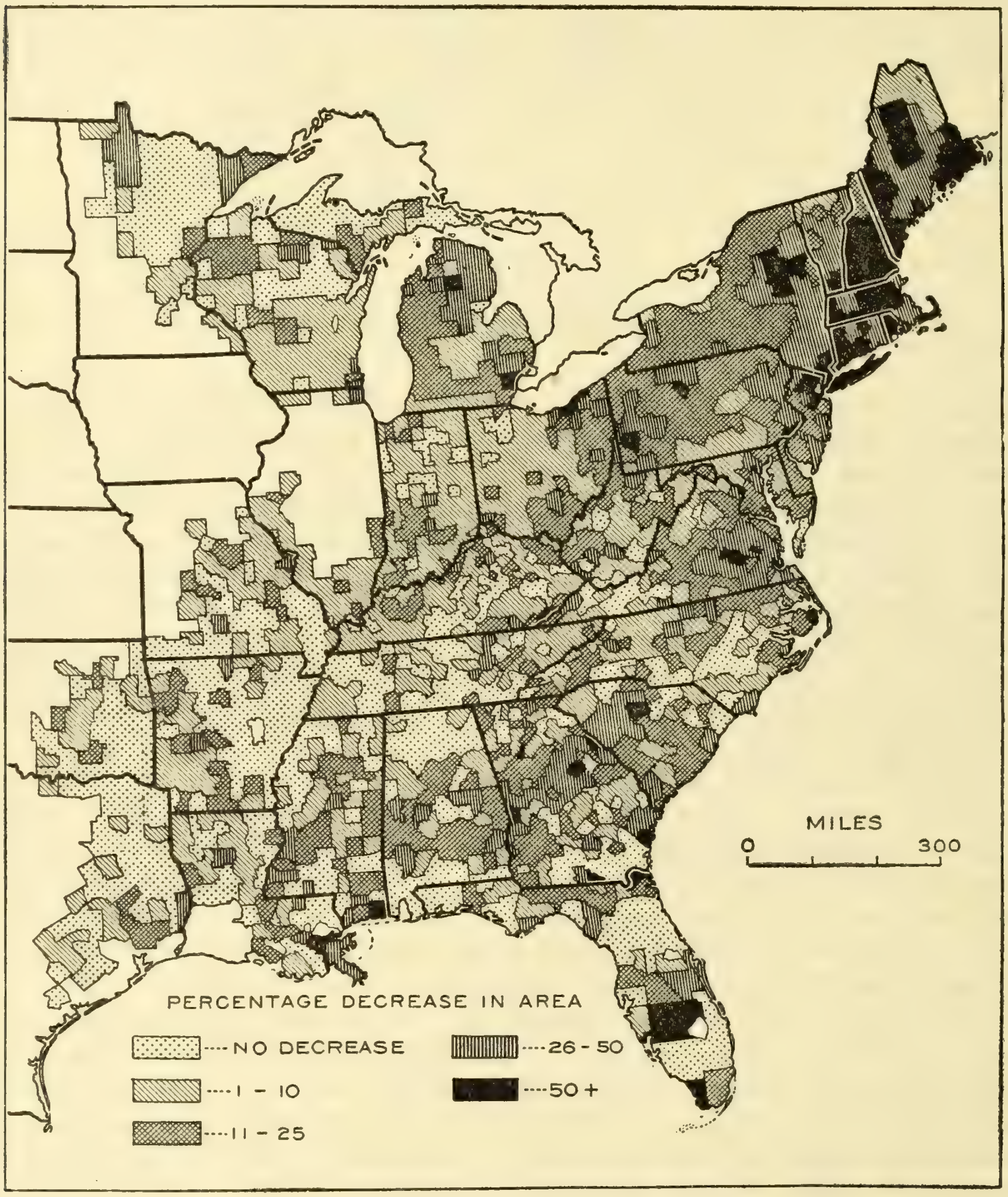

FIGURE 1.—The percentage decrease in agricultural land from the peak to 1930.

ABANDONMENT IN THE DIFFERENT REGIONS

NEW ENGLAND STATES

The abandonment of agricultural land has been greatest, relatively, in New England. This fact has been noted and commented on for more than 50 years. These States were the first to feel the effects on the use of land of the development of manufacturing and the opening up of the lands west of the Alleghenies. The opportunities offered by these developments drew large numbers of people from the rougher and less fertile sections of these States. With the development of this more productive western land, these poorer lands were no longer needed for agricultural production. The area of land used for agricultural production was at its highest in this region in 1880, and has decreased during each decade since that date. (See table 2 and fig. 2.) The amount of land going out of agricultural use in the past two decades has averaged approximately 200,000 acres annually since 1910. (See table 4.) The decline in the use of land for crops has been neither as great nor as uniform as in the case of all agricultural land. The acres of harvested crops declined from 1909 to 1919, an average of 40,000 acres annually, but there was a slight increase for the region as a whole from 1919 to 1924, followed by a decline from 1924 to 1929, averaging 160,000 acres annually. (See table 5.) Allowing for the increase in the first part of the decade (which may be owing in part to the inclusion of many suburban places and other "part-time" farms), the average decline for the decade 1919 to 1929 was 74,000 acres annually.

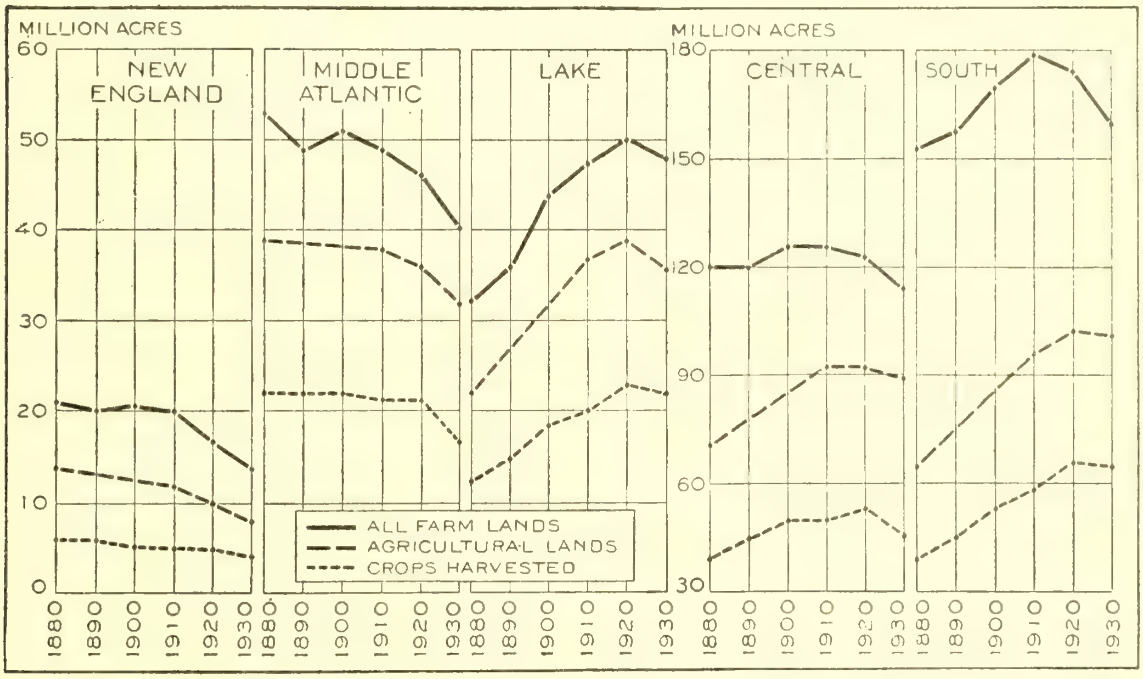

FIGURE 2.—All lands in farms, agricultural lands, and crops harvested, by regions, 1880–1930.

TABLE 5.—*Changes in acres of crops harvested, 1909–24 and in crop land harvested, 1924–29, originally forested counties east of Great Plains*

Region	Changes in acreage of crops harvested [1]				Changes in crop land harvested	
	1909–19		1919–24		1924–29	
	Gross increase	Gross decrease	Gross increase	Gross decrease	Gross increase	Gross decrease
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	58	464	198	130	30	818
Middle Atlantic	484	611	104	1, 841	52	2, 242
Lake	3, 006	78	519	1, 502	407	929
Central	3, 516	475	210	7, 614	813	2, 629
South	9, 303	1, 644	1, 381	8, 258	4, 594	2, 394
Total	16, 367	3, 272	2, 412	19, 345	5, 896	9, 012

[1] Gross increase is total of increases in counties having increases, and gross decrease is total of decreases in counties having decrease during the period.

TABLE 6.—*Idle or fallow crop land, and pasture other than plowable pasture or woods pasture, originally forested counties east of the Great Plains, 1929*

Region	Idle	Other pasture
	Thousand acres	*Thousand acres*
New England	315	2, 155
Middle Atlantic	2, 754	4, 767
Lake	1, 795	4, 627
Central	6, 986	9, 205
South	9, 695	8, 723
Total	21, 545	29, 477

Aroostook County in Maine and the northern counties of Vermont are the only ones which did not show the downward trend. (See fig. 1.) Aroostook County has had a considerable increase both in agricultural land and in crop land since 1900, and the northern Vermont counties show little change.

MIDDLE ATLANTIC STATES

In the Middle Atlantic States also the opportunities outside of agriculture and the competition from the newer agricultural lands were the important factors in briging about abandonment. Prior to the development of industry and railway transportation, pressure of population had forced people to settle on much poor land in these States. Although such lands may have yielded fair returns when first put into cultivation, they soon deteriorated, and the process of abandonment soon began. For this region as a whole abandonment was exceeded by new land being opened up and the total area of agricultural land increased until after 1880. The total area of agricultural land was very nearly the same in 1910 as in 1880. (See table 2 and fig. 2.) The area used for agricultural production probably increased slightly from 1880 to 1890 or 1900, since the total area in farms was greater in 1900 than in 1910. (See table 1.) Data on the area in woodland in farms are not available for 1890 and 1900, consequently the amount of agricultural land being used in those years can not be ascertained. Many of the counties in this region reached the maximum acreage of agricultural land after 1880, most in 1890, 1900, and 1910. There were only seven counties which reached a peak in 1920 and none in 1930. The net decline in agricultural land from 1910 to 1920 for the counties of the region showing a net decrease was at an average of 230,000 acres annually and from 1920 to 1930 the decline averaged 440,000 acres annually. (See table 4.)

The total acreage of crops harvested also varied but little from 1879 to 1909. (See table 3.) There was a slight increase the first decade, a very slight decline during the second decade, and in the third decade, from 1899 to 1909, the decline was somewhat greater, bringing the acreage in harvested crops somewhat below that of 1879. Owing to increased prices during the World War, the acreage in harvested crops in 1919 was only slightly less than in 1909. A decline was reported in a number of counties, but these losses were nearly offset by increases in other counties. Whatever crop land was included in the area of agricultural land that went out of use was almost counterbalanced by the plowing up of pasture for crop production. During the past decade, 1919–29, the decline in crop acreage was almost universal in this region, and totaled over 3,000,000 acres.

LAKE STATES

Agricultural development is more recent in much of the Lake States. For the region as a whole the extent of land used for crop and livestock production reached a peak in 1920. The movement in the three States is following the trend of the development of agriculture from east to west. The peak in the extent of agricultural land was reached in Michigan in 1910, but the decline in that State between 1910 and 1920 was offset by the increase in the other two. (See table 2 and fig. 2.) Although more land was used for agricultural production in Wisconsin and in the originally forested section of Minnesota in 1920 than in 1930, the decline was relatively greater in Wisconsin. The cut-over area of these States is especially significant from a forestry standpoint. The counties comprising this area are less developed agriculturally than are those in the southern part of these States. In a majority of these counties less than half of the area is in farms and a much smaller proportion is actually used for farming, as indicated by the area of agricultural land.

In this cut-over area the individual, and the resources he has or can secure, especially the capital he has or can borrow during the period of development, count for much in the success or failure of the agricultural enterprise. There is certain to be a number who would fail even under favorable conditions, but only a small amount of land would be permanently abandoned unless other conditions made the utilization of the land unprofitable.

Much of the abandoned land in this region was inferior for agriculture when it was cleared; in other cases economic conditions have rendered the land unprofitable. The loss of local markets through the disappearance of the lumber industry and the increased burden of taxes on farms as a result of the loss of local revenue resulting from depletion of the timber supply are important factors in cut-over areas.

In this cut-over region the Michigan section shows the most general and the greatest declines in agricultural land. Many of the cut-over counties of Michigan had more agricultural land in 1910 than in 1920 or 1930. In Wisconsin or Minnesota none of the cut-over counties reached a peak in agricultural area until 1920. In Wisconsin the declines have been more general than in Minnesota. There were decreases aggregating 675,000 acres in counties showing decreases in the three States during the decade 1910 to 1920, while the increases totaled 2,675,000 acres in the other counties. The net increase therefore was 2,000,000 acres. (See table 4.) During the decade 1920 to 1930, the situation was reversed. There was a decline of 3,000,000 acres in counties showing decreases and an increase of less than half a million acres in the other counties, giving a net decline of 2,600,000 acres. The greatest relative decline in agricultural land has occurred in counties in the less developed cut-over region, except where counties have been affected by urban development. (See fig. 1.)

CENTRAL STATES

The peak in agricultural land in the Central States was reached in 1920. (See table 2 and fig. 2.) The increase above the acreage in 1900 and 1910 was not large. In general, most of the land suitable for agriculture had been put to that use by 1900. The variation in development is greater than in the two northeastern regions. A number of the Ohio counties reached their peak in 1880, and some counties, especially in Missouri and Tennessee, had a greater acreage in 1930 than in any previous year, but in most counties the acreage of agricultural land increased up to 1910 or 1920 and then declined before 1930. The decline in most counties has been relatively small, and for the region as a whole, although large in the aggregate, is relatively much less than for New England or the Middle Atlantic States. The counties showing important declines are scattered. (See fig. 1.)

The decrease in agricultural land in a number of counties has been due to urban or mining development. Outside of these counties the greatest falling off in land used for agricultural production has been in southeastern Ohio and the adjacent portion of West Virginia. Scattered counties in other parts of the region also show considerable declines, particularly in southern Indiana, southern Illinois, some of the counties in the Kentucky coal area, and in the Cumberland Plateau of Tennessee. Erosion has been an important factor in rendering much of this land unprofitable. In many areas it has been by far the major factor.

Between 1910 and 1920, the decrease in the agricultural area in the counties of the Central States reporting a decrease was 1,800,000 acres, while in the counties reporting increases the gain was 2,700,000 acres. The net increase, therefore, was almost 1,000,000 acres. Since 1920 the decrease has been substantial. The gross decline was 4,900,000 acres and the net decline was 3,500,000 acres, there being an increase aggregating 1,400,000 acres in a number of counties.

The peak in crop acres in the region as a whole was in 1919. (See table 3.) As with agricultural land, the total was not much greater than 20 years earlier. The crop area increased somewhat at the expense of the pasture acreage from 1909 to 1919, and the decline in crop acreage has been relatively greater, indicating that some of the crop area has gone back to pasture. This is particularly true of much of Ohio, Indiana, southern Illinois, and northwestern Missouri. For some of these counties it may indicate the beginning of the process of abandonment, if the land cannot compete with other areas as pasture land. The acreage of all land in farms has declined relatively more rapidly than the acreage of agricultural land. (See tables 1 and 2.)

SOUTHERN STATES[4]

The extent of agricultural land was at its height for the Southern States in 1920. (See table 2 and fig. 2.) There was only a small decline for the region as a whole to 1930. The variation in the region is so great that the totals do not give a true picture. The peak in the amount of agricultural land for Virginia, North Carolina, South Carolina, and Alabama was reached in 1910; in Georgia, Florida, and Mississippi, in 1920, while for the States in this region west of the Mississippi there was more agricultural land in 1930 than at any previous census date. The counties of the coastal plain of Virginia had more agricultural land in 1880 than they have had at any time since that date. The amount of abandonment has been greatest there, and has been heavy in many of the counties on the coast in the States to the South, and in the sandhill region from North Carolina through Georgia, in central Alabama, in the sugar-bowl parishes of Louisiana, and in the loessial hill section of Mississippi, beginning in the southwest corner of the State and running northeast almost across the State. (See fig. 1.)

In the past two decades there have been heavy declines in some of the Piedmont counties and in some of the counties in northern and in southern Florida. The counties in central Florida have shown little change. Much of this region is subject to very heavy erosion, which in many counties is the major factor in bringing about abandonment. The boll weevil has been an important cause of abandonment in areas of heavy soil. In other areas the competition of more productive land to the west has led to abandonment and to the migration of farmers and farm laborers to areas where the opportunities appeared more favorable.

From 1910 to 1920 there was a total decline in agricultural land of nearly 4,000,000 acres in counties reporting a decline in this forest region, but the increase in other counties was nearly 10,000,000 acres, resulting in a net increase of nearly 6,000,000 acres. (See table 4.) Some counties in every State showed a decrease, but the greatest declines occurred in Virginia, North Carolina, South Carolina, Georgia, and Alabama. Each State had a gross decline totaling over 500,000 acres. In Georgia the increases (in counties having increases, totaled over 1,500,000 acres. In this decade the increases in counties in Florida, Arkansas, and the originally forested portions of Oklahoma and Texas also exceeded 1,000,000 acres in each State.

From 1920 to 1930 the net decline in the originally forested counties in this region was only 1,000,000 acres, but the total decrease in counties showing declines was almost 6,500,000 and the total increases in the other counties nearly 5,500,000 acres. In each of the States east of the Mississippi, except North Carolina, the total decline in counties in which decreases occurred exceeded 500,000 acres. In North Carolina there was a slight net increase between 1920 and

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[4] For Oklahoma and Texas only the eastern counties are included.

1930. The increases in agricultural land in this decade occurred mainly in the Mississippi delta and in the originally forested counties of Texas. In the other States the increases in counties showing increases totaled less than 500,000 acres per State. The decreases were especially great in Georgia where over 1,500,000 acres went out of agricultural production, a net decrease of over 1,000,000 acres. More than 500,000 acres went out of agricultural production in each of the States of Virginia, Florida, Alabama, and Mississippi during this decade.

The crop acreage in this region increased steadily until 1920; since then there has been a slight decrease. The decline has been greatest in Georgia where the acres of crops harvested were 1,500,000 less in 1929 than in 1919.

FUTURE REQUIREMENTS FOR AGRICULTURAL LAND

The area of land needed for agricultural production in the future will depend in large part upon the demand for agricultural products. The factors that will effect alterations in demand are: Changes in the population, changes in per capita consumption in the United States, and changes in exports to foreign countries. The aggregate per capita consumption of food products has not changed much in this country during the past 25 years. There have been shifts in consumption from one food to another, but the aggregate has not varied more than 7 percent from the average and usually the annual variation has been within 4 percent. The same has been true of cotton except that in recent years there has been some reduction as a result of the competition of rayon.

The most important factor effecting changes in the amount of agricultural production required has been the increase in our population. Therefore, the probable increase in our future population will be very significant in determining the probable future demand for agricultural products. The number of births has been declining in the United States, and students of population believe it unlikely that the birth rate will rise. They expect that unless immigration restrictions are removed the population of the United States will be slightly over 130,000,000 by 1940 and about 140,000,000 by 1950.

The outlook for the export demand is much more uncertain. Agricultural exports have gone largely to northwestern Europe. There, too, the birth rate is declining and a stationary population is expected in 20 to 40 years, occurring earliest in Sweden, Germany, and England. In France the population has been about stationary for 70 years. In these countries, as in the United States, the rural birth rate is greater than the urban. The realization of this fact, taken in connection with the nationalistic spirit, may cause these countries to give consideration to the means of maintaining as large an agricultural population as possible. They may seek to accomplish this by becoming more self-supporting with respect to foodstuffs. Since the beginning of the century there has been increasing competition for the markets of northwestern Europe. Take England, the leading market for our agricultural products, for example. Thirty years ago 29 percent of its imports came from the United States and 24 per cent from the British possessions, whereas today 15 percent of the imports come from the United States and 40 percent come from the British possessions.

The situation with respect to exports to other parts of the world, such as the Orient, is even more difficult to appraise.

Considering these factors, it appears reasonable to assume that there will be no significant change in aggregate per capita consumption of agricultural products, and as a result our domestic consumption will increase in proportion to the population; and that agricultural exports will remain equivalent to 5–15 percent of the Nation's production. This has been the situation for the past 25 years, except that exports exceeded 15 percent of production during the few years of, and immediately following, the World War.

Total agricultural production, although fluctuating, has increased at very nearly the same rate as population during the period since 1908. If total agricultural production should continue to keep pace with population it will probably not, however, increase in this and the next decade at the rate it has in the past two decades. As has been stated, students of population expect that, unless immigration restrictions are removed, the population will be only about 8 percent greater in 1940 and possibly 14 percent greater in 1950 than in 1930. This increase compares with an increase of 16 percent between 1920 and 1930 and an increase of 33 percent between 1910 and 1930.

The increase in agricultural land required to provide this additional production will depend upon several factors which will be discussed later. It seems very probable that it will not be necessary to increase the total area of agricultural land even 8 percent between 1930 and 1940, nor 14 percent by 1950, to provide for this additional supply. In the decade, 1920 to 1930, agricultural production [5] increased 20 percent and for the two decades, 1910 to 1930, approximately 35 percent.

This increase in agricultural production in the United States was secured with a net increase in agricultural land in farms in the country as a whole of only 6 percent during the last decade and of only 18 percent during the two decades.[6] The area of crop land increased less rapidly. In the decade, 1920 to 1930, the area in crops harvested increased very little, if at all,[7] and in the 2 decades since 1910, it increased approximately 13 percent. It is well within the realm of possibility, if not probability, to increase agricultural production 8 percent without any addition to the area of agricultural land.

Technical changes affecting agriculture have made it possible to increase agricultural production without increasing the agricultural area to the same extent. This increase in production is not due in any appreciable extent to increased crop yields per acre. For the Nation as a whole the composite acre yields of the leading crops has not increased since the period 1905–9. Four other factors have been largely responsible for agricultural production expanding more rapidly than the agricultural area. These are (1) the great decline in horses and mules, which has released for the production of human food large areas formerly required to produce feed for the work stock, (2) the increased efficiency in the production of meat and milk, much less feed being used now per pound of product, thus requiring less land; (3) a shift from less productive crops per acre to the more productive; and (4) a shift from less productive to more productive livestock per unit of feed consumed.

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[5] By agricultural production is meant the net production available for human consumption and for export. The production of feed crops consumed by domestic livestock is deducted from total crop production.

[6] This increase in agricultural land was nominal rather than real, for nearly all the increase has occurred in the Great Plains region by the inclusion in farms of former range land.

[7] The total area in harvested crops as reported by the census is not directly comparable one census year with another. The acreage of comparable crops for 1929 shows a slight decline from 1919 as reported by the census. The estimates of the Department of Agriculture for the same years show a slight increase. The change according to either estimate is less than 1 percent.

The changes that will occur in agricultural technique will depend upon economic conditions and the introduction of new methods and the discoveries of science. It may be expected that development of new methods and new discoveries of science will continue. The extent to which such developments will affect agriculture will depend in an important degree upon economic conditions. The relation of the prices of agricultural products to the prices of the items that enter into their production and the relation of the prices of the various cost items to one another will largely determine the changes in technique actually adopted. The changes that may occur in this complex of economic conditions and technical developments and the effect of these on land requirements are very uncertain. If, for example, horses should become a more economic source of power than tractors, land now used for the production of human food or for export products would be required to feed the extra horses. A much larger agricultural area, therefore, would be required.

Of all the factors affecting the future land requirements for agriculture, perhaps the most difficult to appraise are the future changes in economic conditions and in technology. If these economic and technical forces continue to act as they did during the decade 1920 to 1930, it will not be necessary to increase appreciably the total area of agricultural land or of crop land to provide the increased agricultural products required by the expected increase in population. If these economic and technical changes do not act as forcefully as during the last decade, but are comparable to the average for the two decades 1910 to 1930, it would be necessary by 1940 to increase the total agricultural area by possibly 20,000,000 acres and the crop area by 8,000,000 to 10,000,000 acres and by 1950 to increase the agricultural area by about 35,000,000 acres and the crop area by 14,000,000 to 18,000,000 acres.

It is probably better to plan for much less than the maximum increase, as shown above, in both agricultural land and crop land. Expansion can be brought about rather quickly if conditions point to the need for more agricultural land, and the social costs of an error of underestimation are not likely to be so great as from an overestimate. It is more difficult to grow trees than to remove them, and it is easier to secure new settlers than to absorb the losses from labor and capital directed in a mistaken enterprise. There is a considerable loss in reclaiming and improving land if that land is not needed, and there is loss in maintaining schools and roads for 1 or 2 settlers where a dozen or more farms had been expected.

FUTURE ABANDONMENT IN ORIGINALLY FORESTED REGIONS EAST OF THE GREAT PLAINS

It appears reasonable to expect that in the future as in the past some agricultural land will be abandoned while other land is being brought into use. This will occur regardless of whether the total area of agricultural land increases, remains stationary, or declines. New land will be brought into use through clearing, through promotion of settlement by land-selling agencies, through mechanization and other changes in technique. Some of the land now operated will be abandoned because of the effect of changes in physical condition, such as erosion, and because of economic changes that will make the land no longer profitable; that is, the same factors which were spoken of as having brought about abandonment, and perhaps other factors, are likely to be manifested in particular regions in the future as in the past.

Even during the decade 1920 to 1930 some new land was brought into use in these originally forested regions east of the Great Plains. In the counties that showed increases over 1920 there were 7,000,000 acres more of agricultural land. In those counties in which the agricultural land was less in 1930 than in 1920 some new land was brought into cultivation, but the amount was relatively insignificant.

The only data that give any indication of the new land brought into use in those counties are the data on land cleared and made suitable for crops between 1920 and 1925, as reported by the Census of Agriculture for 1925. The total cleared in the 5-year period in the eastern forest regions was 3,500,000 acres. Little of this acreage was in the New England or Middle Atlantic States. The larger part was in the South, where many counties showed more agricultural land in 1930 than in 1920. The important expansion in the agricultural area during this period did not occur in the originally forested regions east of the Great Plains but in the Great Plains. This expansion was due in large part to the advances in mechanization of agriculture which made possible the production of wheat and cotton at a lower cost than in the older production areas and helped to bring about abandonment in these older areas.

In addition to this expansion in the West the large exodus of persons from farms to cities up to 1929, because of the relatively more prosperous condition of urban pursuits as compared with agricultural, was important in bringing about abandonment in the originally forested regions. The mechanization of agriculture is not now proceeding as rapidly, at least during this depression, and the counter movement of population from cities to the farms has exceeded the movement from farms to cities in 1930, 1931, and 1932.

Whether the present movements are only temporary is, of course, difficult to foretell, since the outcome depends largely on the extent to which industrial unemployment is eliminated in the processes of economic recovery. If this exodus from the city lowers labor costs in relation to machinery costs to the point at which it is more profitable to produce a large quantity of agricultural products with more labor and less machinery, then the expansion in the Great Plains and other areas where agriculture is profitable under high mechanization will not take place so rapidly as was true in the years just preceding 1929. It is probable that there will be some increase in part-time and subsistence farming by the movement of urban workers back to the land. This movement will not appreciably affect the total land requirements for agriculture since the amount of land used for agriculture per family for part-time and subsistence farming is comparatively small. It will tend to put some land in cultivation or prevent some land from being abandoned near urban centers. The shifts that will occur in land utilization will depend upon the changes that occur not only in agriculture but in industry, in transportation, and in all lines of economic activity.

Agricultural shifts have constituted the most influential factor in effecting the abandonment of land for agriculture. It is possible that during the coming decade mechanization of agriculture and exodus of farm population to cities may not operate to bring about farm abandonment to the extent that they did from 1920 to 1930. The facts that population probably will not increase so rapidly as in the past decade and that exports do not promise to expand rapidly may make the pressure of competition of lower-cost areas on higher-cost areas more severe. Increased efficiency in production through better livestock, better crops, greater use of fertilizer, etc., may also intensify interregional competition. Erosion, unless checked, will probably also bring about more and more abandonment.

AGRICULTURAL LAND AVAILABLE AND TO BE AVAILABLE FOR REFORESTATION IN THE ORIGINALLY FORESTED REGIONS EAST OF THE GREAT PLAINS

Any estimate of the amount of agricultural land available for reforestation can be only a very rough approximation. The previous discussion has shown that many factors have and will influence the amount of agricultural land available for reforestation. Data are not available to show how much agricultural land was abandoned prior to 1910, but in the discussion of land abandonment it was estimated that over 30,000,000 acres of land have gone out of agricultural production since 1910 in the originally forested regions east of the Great Plains. Some of this land has been put to residential or other intensive use, some has already grown up to forest; the remainder is largely idle and available for reforestation. There is considerable variation in the quality of this land for forestry production, and this variation would be considered in determining a forestry program for such land.

In addition to this abandoned agricultural land, 21,500,000 acres of land were designated as idle or fallow crop land still in operated farms, in 1930, in these regions. (See table 6.) Much of this land is in the first stage of abandonment and is largely available for consideration in the development of a forestry program.

A third class of land which contains a considerable area that might be available for reforestation is that reported by the census as "pasture other than plowable or woodland pasture". In 1929 there were 29,500,000 acres of such land in farms in the forest regions. (See table 6.) Much of this is in an advanced stage of abandonment, although still being utilized to some extent in agricultural production.

Natural reforestation of land comes about rather slowly. It is probable that little of the land abandoned since 1920 has been reforested and that much of the land abandoned between 1910 to 1920 is available for reforestation as well as some of the land abandoned prior to 1910. Although it is impossible, in the absence of actual surveys, to determine the extent of agricultural land available for reforestation, it seems reasonable to assume that most of the land abandoned since 1920 and perhaps half of that abandoned between 1910 and 1920 might be considered available for this purpose. If, in addition, half the idle crop land is added and half the pasture not already in woods or not plowable, there is a total of over 50,000,000 acres of agricultural land that might be available for some type of reforestation. As this includes no estimate for land abandoned prior to 1910, it would seem to be a conservative figure.

This area available for reforestation will be increased by the land that will be abandoned during the next two decades. It has been stated previously that abandonment is not likely to be so great as during the decade 1920 to 1930, but is likely to be greater than during the decade 1910 to 1920. If land should be abandoned at the average rate of the two decades there would be approximately 15,000,000 acres more by 1940 and nearly 30,000,000 acres by 1950. Some of this abandonment will come from the idle crop land and the pasture land listed above. However, some of the land now being utilized intensively may be in one of the two stages of abandonment. It seems reasonable then to expect approximately 75,000,000 or 80,000,000 acres of agricultural land to be available or likely to be available by 1950 for some degree of reforestation.

It should be noted that this is probably a maximum estimate. Improvements in the economic position of agriculture may reduce the total. Moreover, much of the area statistically available might prove to be not economically available. Inertia of farm owners may retard the reforestation of some of the idle land in farms in cases in which the entire farm is not abandoned. In some areas the abandoned farms may be too widely scattered to permit the consolidation of workable forest units, while in still other areas the idle farm land may not prove well adapted to reforestation at reasonable costs either to private or to public agencies.

SOME SOCIAL AND ECONOMIC PROBLEMS OF FARM ABANDONMENT

A number of important and rather distinctive social and economic problems are encountered in areas of extensive abandonment and in areas containing substantial amounts of land unsuited to farm use. Some of the more important social ills of these areas are: (1) Low incomes and consequent low plane of living, (2) fiscal difficulties of local government units, (3) low plane of community life, and (4) waste of individual and social effort and exploitation of those ignorant of the lack of opportunity existing in such areas. These difficulties are all interrelated and each in turn has an effect upon the others.

The living generally possible in such areas is usually on a lower plane than in better areas. It is the hope of securing a better living elsewhere that has led to much abandonment. A number of studies in such areas have shown that the incomes of the farm families are notably less than the incomes of farm families in better agricultural areas. In one study, the goods purchased for consumption averaged $324 per family compared with an average of $914 in more favorable areas.[8]

Another study of several areas of extensive abandonment showed an average income of only $339 for the labor of the farmer after allowing for farm expenses and only $98 after deducting 5 percent for interest on investment.[9] The gross income per farm of a county in still another State, in which there was much poor agricultural land, was only slightly more than 50 percent of the average for the State.[10] In areas of eventual abandonment people hold on for some time after conditions have become relatively unsatisfactory in the hope that these conditions are only temporary. This results in still further lowering the plane of living.

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[8] Oyler, M.—Cost of Living and Population Trends in Laurel County, Ky., 1930. Ky. Agr. Expt. Sta. Bul. 301, p. 73.

Kirkpatrick, E. L. and Hawthorne, H. W.—Sources and Uses of Income Among 300 Farm Families of Vinton, Jackson, and Meigs Counties, Ohio, 1926. U.S.D.A. Bur. Agr. Econ. Min. Rept., p. 9.

[9] Vaughn, L. M.—Abandoned Farm Areas in New York, 1928. Cornell Agr. Expt. Sta. Bul. 490, p. 255.

With low incomes it is difficult to finance local governmental services like schools and roads. In addition, the costs per farm for roads, and per pupil for schools, are much higher in areas of abandonment than in areas of better agriculture because of the sparse population served. If the costs are kept down it is only by sacrificing quality through shorter school terms, poorly trained teachers, etc. The policy of granting State aid has been adopted to insure at least a minimum of such services. Consequently the conditions necessitating aid are of more than local interest, especially in view of the fact that such aid serves to encourage the continued occupancy of or stimulates new settlement in areas incapable of supporting a reasonable standard of living.

A study in one State showed that in a number of school districts the tax receipts for school purposes from sources other than the local farms were sufficient, if capitalized, to purchase all the farms in the districts and in some districts they would leave a balance of $2,000 per farm.[11] Another State is paying to some of its townships out of the State treasury annually, sums for schools alone equal to 20 percent of the assessed value of the townships. This constitutes the net payments above the total of the towns' share of State taxes.[12] Of the school cost of nearly $3,000 in one year, in a town of still another State, the local residents paid only $236.[13]

It is believed that economies can be effected in many instances in the costs of schools and roads if the State aid for these purposes is coordinated with a rational plan of land utilization. The policies should be coordinated to encourage the use of the poorer and more isolated areas for forests and for recreation, by discouraging settlement for agriculture, and by making it easier for those already in such areas to go where opportunities are more favorable.

Another fiscal problem in many areas is tax delinquency.[14] It is more important in the cut-over timber areas than in most of the areas of extensive abandonment, for here timberland owners are allowing their cut-over lands to go tax-delinquent by the thousands of acres. It affects agriculture even where the area of agricultural land that is tax-delinquent may be relatively small. The burden of taxation on agriculture is increased because of the lessened tax base and the shifting of the tax burden to the lands on which the taxes are paid. The tax delinquency becomes a factor in bringing about further tax delinquency and is a contributing cause of agricultural abandonment.

Not only is it difficult to maintain schools and roads in areas having large amount of submarginal agricultural land, but the same factors make it difficult to maintain churches and other social and economic organizations. The lack of services, or the poor quality of services, rendered by these social and economic agencies result in a low plane of community life. In a locality in which there has been abandonment of 25 to 50 percent or more of the agricultural land, with a resulting decrease in the farm population, it is evident that although it may have been possible to support adequate social services prior to the beginning of abandonment it is no longer possible to do so. Many churches and other organizations have disappeared or gone out of use with a resulting loss to the community.

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[10] Wisconsin Agricultural Extension Service. Making the Most of Washburn County Land. 1932. Wis. Agr. Ext. Service Special Cir., p. 10.

[11] Peck, M., Frank, B., and Eke, P. A.—Economic Utilization of Marginal Lands in Nicholas and Webster Counties, W.Va. 1932. U.S.D.A. Tech. Bul. 303, p. 24.

[12] Indiana, State of; Yearbook of Indiana. 1930. p. 505.

[13] Hibbard, B. H., Hartman, W. A., and Sparhawk, W. N.—Use and Taxation of Land in Lincoln County, Wis. 1929. Wis. Agr. Expt. Sta. Bul. 406, p. 19.

[14] The tax delinquency referred to here is not the temporary tax delinquency which is rather wide-spread but that stage where the land reverts to the State or county.

It is the younger people who most readily leave such areas. The older people find it more difficult to break their ties with the community. All their capital is invested there, their friendships are there, and often they are unaware of opportunities elsewhere; or they feel that considering the difficulties of moving and starting over, they would be no better off after making the change. These same considerations tend to hold the young people in the area but to a much less extent. A study of abandoned farm areas,[15] referred to previously, states that on 47 percent of the farms there were no children and there were only 49 boys and young men over 20 years of age on the 510 farms in the areas. The community loses the stimulus and enthusiasm of the young people and in some instances all the potential leaders leave the community.

The only apparent reason why some communities with no more favorable natural conditions than others have not been abandoned is that the quality and leadership of the population has been maintained. The process of decay in social life may go to the point where a virtual rural slum exists, with all the associated evils.

The loss to the individual and to society through attempting to utilize submarginal land like that in areas of extensive abandonment, although not large in comparison with the total resources of the country, is nevertheless important to the individual involved and to the county and to the State in which these areas are found. Often the same effort applied by the individual in other areas or in other occupations would result in a larger return to himself and to society. Similarly, investing the same amount in roads and schools in other areas would secure a greater return to society for the money expended. The areas of abandonment and other areas containing submarginal land are particularly fruitful fields for unscrupulous real-estate operators and land companies. Abandoned agricultural land, or land which should be abandoned, is sold to persons unacquanited with local conditions. These persons attempt to eke out a living for a time; then abandon the land or sell to some one equally ignorant of the possibilities; then the process is repeated. The turnover in ownership in such areas is very high. In each transfer there is a loss of the accumulated savings which are invested, and a lowering of the standard of living, resulting in disappointed and discouraged families and dissatisfaction with existing social conditions. This shifting of the population adds to the difficulty of maintaining a vigorous community life in areas which had already found it difficult to maintain themselves.

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[15] Vaughn, L. M.—Abandoned Farm Areas in New York. 1928. Cornell Agr. Expt. Sta. Bul. 490, p. 250.

TIMBER RESOURCES AND REQUIREMENTS

The purpose of the three following sections, on present and potential timber resources, our national timber requirements, and trends in world wood consumption, in conjunction with the preceding sections dealing with the forest-land resource, is to present the basic facts of the present and potential timber-supply phase of the forest situation of the United States. Here is laid the essential foundation for the formulation of a national-forest policy and programs of action for coordinating the economic use of the Nation's forest land with future normal requirements for timber.

The first section deals with the volume and availability of existing stands; the rate at which these are being used up either through cutting or through losses from fire, disease, or insects; the extent to which this combined "drain" on the forest is being offset by growth; the potentialities of sustained yield under different intensities of forest management; and the comparison of these potential yields and potential normal timber requirements.

The second section, using past consumption as a guide but not as an absolute measure, treats of normal requirements for lumber, pulpwood, and other major timber products, and the trends in wood use and the factors which affect these trends. The discussion of trends in world consumption of wood products treats of the tendency of certain trends to offset others, the long-time upward trend of aggregate consumption, and the future potentialities that appear to exist for the United States to enter foreign softwood markets on a larger scale.

PRESENT AND POTENTIAL TIMBER RESOURCES

By R. E. Marsh, In Charge, Division of Forest Economics, and
W. H. Gibbons, Senior Forester [1]

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The country's forest resource consists of two fundamental elements, namely, the forest land as such, which is treated in the section on "Forest Land the Basic Resource," and the forest growth which that land bears. The amount, character, geographic distribution, ownership, economic availability, rate of cut or destruction, and rate of growth, of this stand of timber are of the utmost importance, because upon them largely depend the assurance of meeting economically, amply, and permanently our needs for timber and timber products and for other forest benefits. They determine the degree to which the forest resource, land and timber, is approaching its potential contribution to the Nation's economic welfare. They influence the determination of whether and what positive measures are needed, nationally and regionally, both by the private owner and the public, to put the forests on a satisfactory basis. It is the purpose of this discussion to present the best information available as to the timber stands on the 495 million acres classed as commercial forest land.

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[1] Valuable contributions in analysis and interpretation of the growth data presented in this section were made by E. N. Munns. C. E. Behre, and W. N. Sparhawk. Acknowledgment is also due to R. V. Reynolds for assistance in the development of the data on forest drain, and to W. D. Brush for cooperation in the compilation of the data throughout this section.

PRESENT TIMBER SUPPLIES

VOLUME AND DISTRIBUTION

SAW TIMBER

Saw timber deserves first attention. Of the broad classes of forest growth, saw timber is in greatest demand, being required for lumber, crossties, veneer, and similar sawed or sliced products. The long periods required in its production, moreover, aggravate the problems of those attempting to apply systematic forest land management, particularly in the case of private owners.

The present estimate of saw timber on commercial forest land in the United States is 1,668 billion board feet (board foot estimates based on lumber tally). (Table 1 and figs. 1, 2, 3, and 4.) Of this, 1,346 billion board feet, or 80 percent, is old growth and represents the remainder of the original stands that have been crudely estimated as at least 5,200 billion board feet. The original forest growth on possibly 150 million acres was destroyed in clearing the land for agriculture in the early days. The volume of old growth cut for lumber since those early days has been estimated at 1,650 billion board feet. Cuttings for other purposes and continuous losses through fire, disease, and insects have taken the rest. Old growth—characteristically two or three hundred, often several hundred years old—still dominates the lumber market, but its days are numbered. It is doubtful that man will ever grow, as Nature has grown, extensive crops of fully mature trees, such as will furnish the strong and durable timbers of large dimensions and the high proportion of clear products that have commanded the best markets in the past and given lumber its high rank as a valuable construction material.

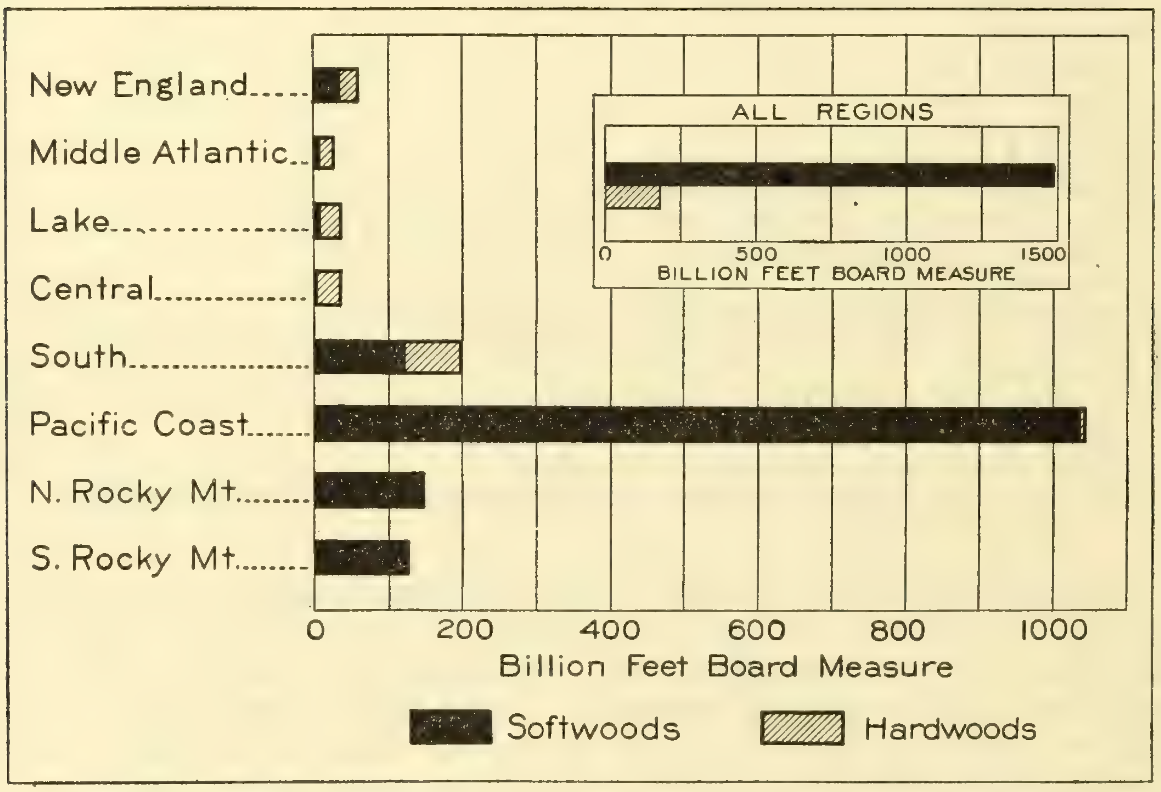

FIGURE 1.—Softwood and hardwood saw-timber stands of the United States by regions.

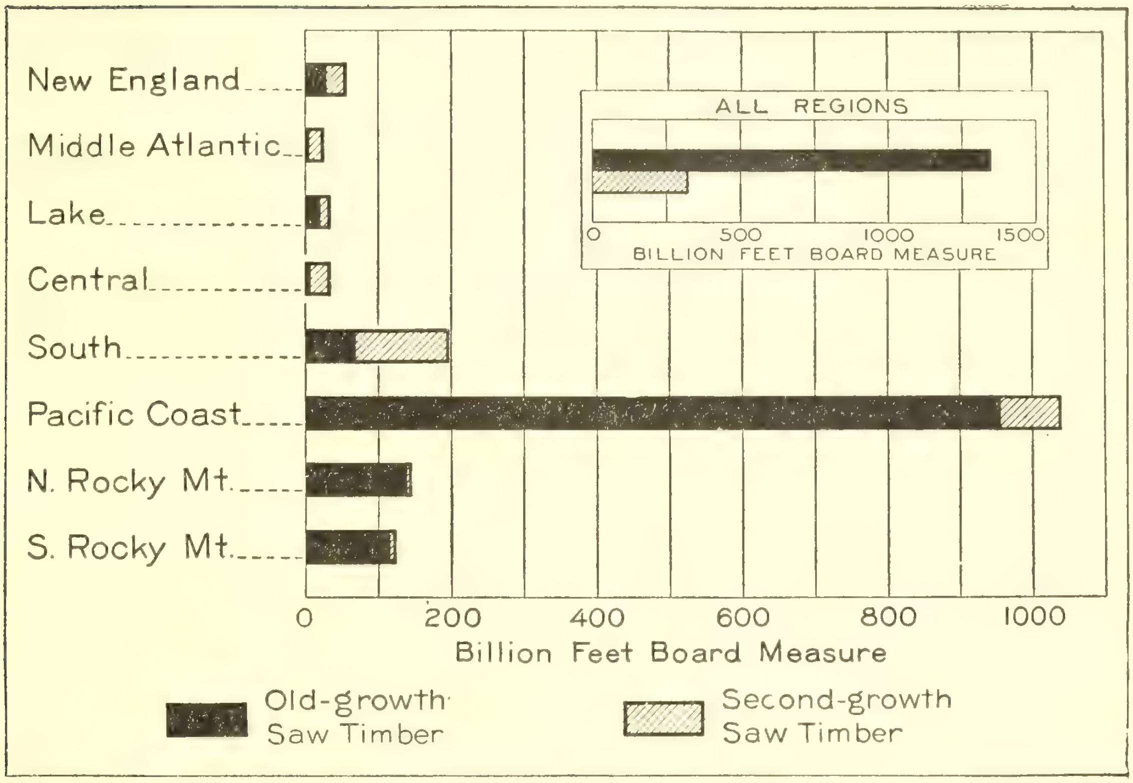

FIGURE 2.—Old-growth and second-growth saw-timber stands of the United States by regions.

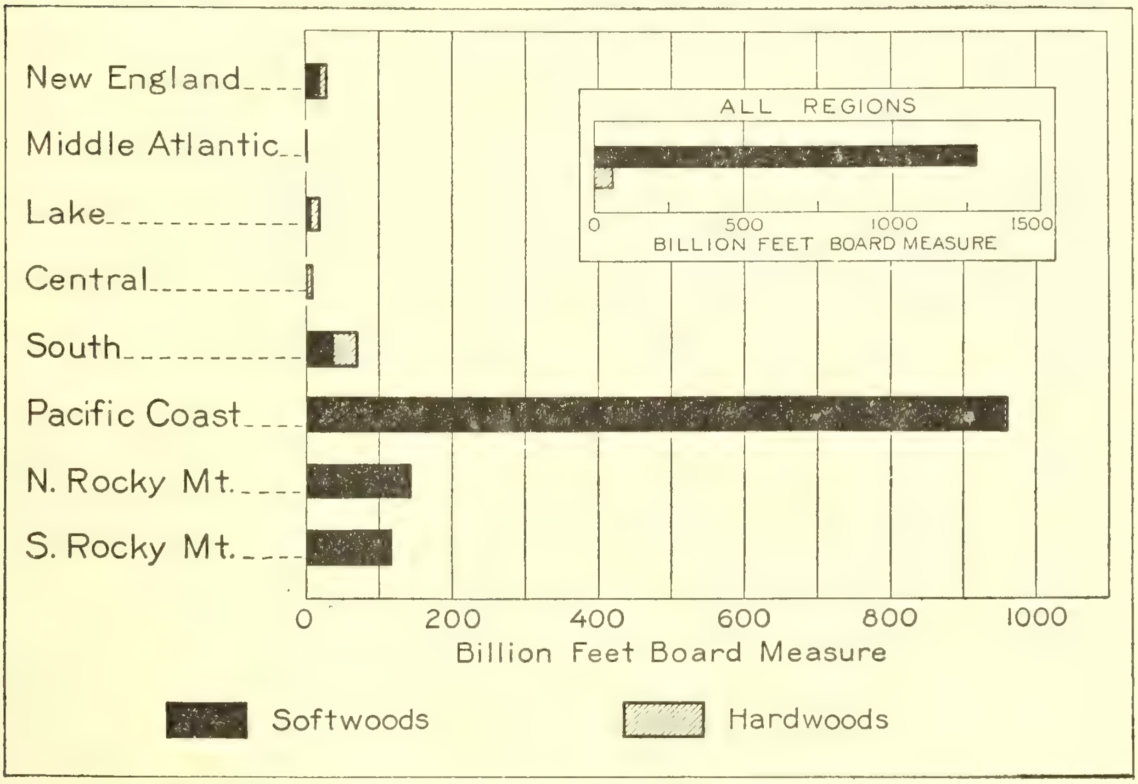

FIGURE 3.—Old-growth saw-timber stand of the United States by regions.

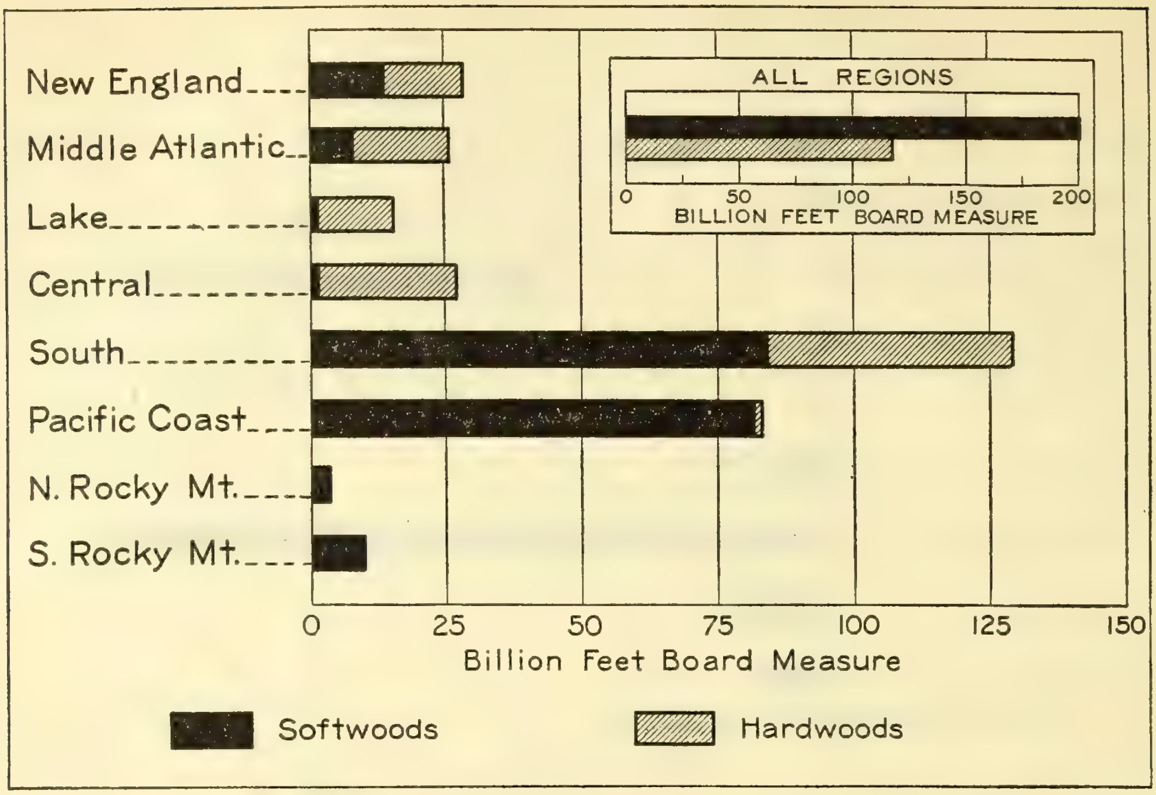

FIGURE 4.—Second-growth saw-timber stand of the United States by regions.

TABLE 1.—*Stand of saw-timber in the United States, by character of growth and region*

[In million feet board measure]

Region	Total		Softwoods			Hardwoods		
			Total	Old growth	Second growth	Total	Old growth	Second growth
		Percent						
New England	57, 875	3	32, 811	18, 977	13, 834	25, 064	10, 295	14, 769
Middle Atlantic	26, 150	2	8, 245	144	8, 101	17, 905	195	17, 710
Lake	35, 887	2	9, 193	7, 656	1, 537	26, 694	13, 327	13, 367
Central	34, 622	2	2, 900	1, 146	1, 754	31, 722	6, 332	25, 390
South	199, 297	12	121, 449	37, 312	84, 137	77, 848	32, 866	44, 982
Pacific Coast	1, 041, 628	62	1, 038, 909	957, 208	81, 701	2, 719	1, 421	1, 298
North Rocky Mountain	146, 388	9	146, 388	142. 680	3, 708	--------	--------	--------
South Rocky Mountain	125, 956	8	125, 955	116, 215	9, 740	1	1	--------
Total	1, 667, 803	100	1, 485, 850	1, 281, 338	204, 512	181, 953	64, 437	117, 516

The volume of second-growth saw timber is far too small for a desirable balance with old growth, cordwood, and smaller growth, considering the large proportion of the total forest area that has been cut over. This is in part because of the practice in important regions like the South, of cutting the second-growth trees as soon as they reach merchantable size, but before they have reached physical or economic maturity. It is also due to the all too prevalent lack of interest in maintaining the continued productivity of the land following cutting, whether of old growth or second growth. A third cause is fire, which prevents or delays restocking on millions of acres of cut-over lands and retards growth even after a new stand is established.

The steady progress of the lumber industry from the Northeast and Lake States to the South and in turn to the West is reflected in the heavy depletion of the eastern saw-timber stands and the location of the bulk of the remaining saw timber in the West. Thus, the New England, Middle Atlantic, Central, and Lake regions with 35 percent of the commercial forest land contain only 9 percent of the saw timber, the South with 39 percent of the area contains but 12 percent, while the West with 26 percent of the area contains 79 percent of the saw timber, and nine tenths of the old growth. The Pacific Coast region alone has 13 percent of the area and 62 percent of the saw timber.

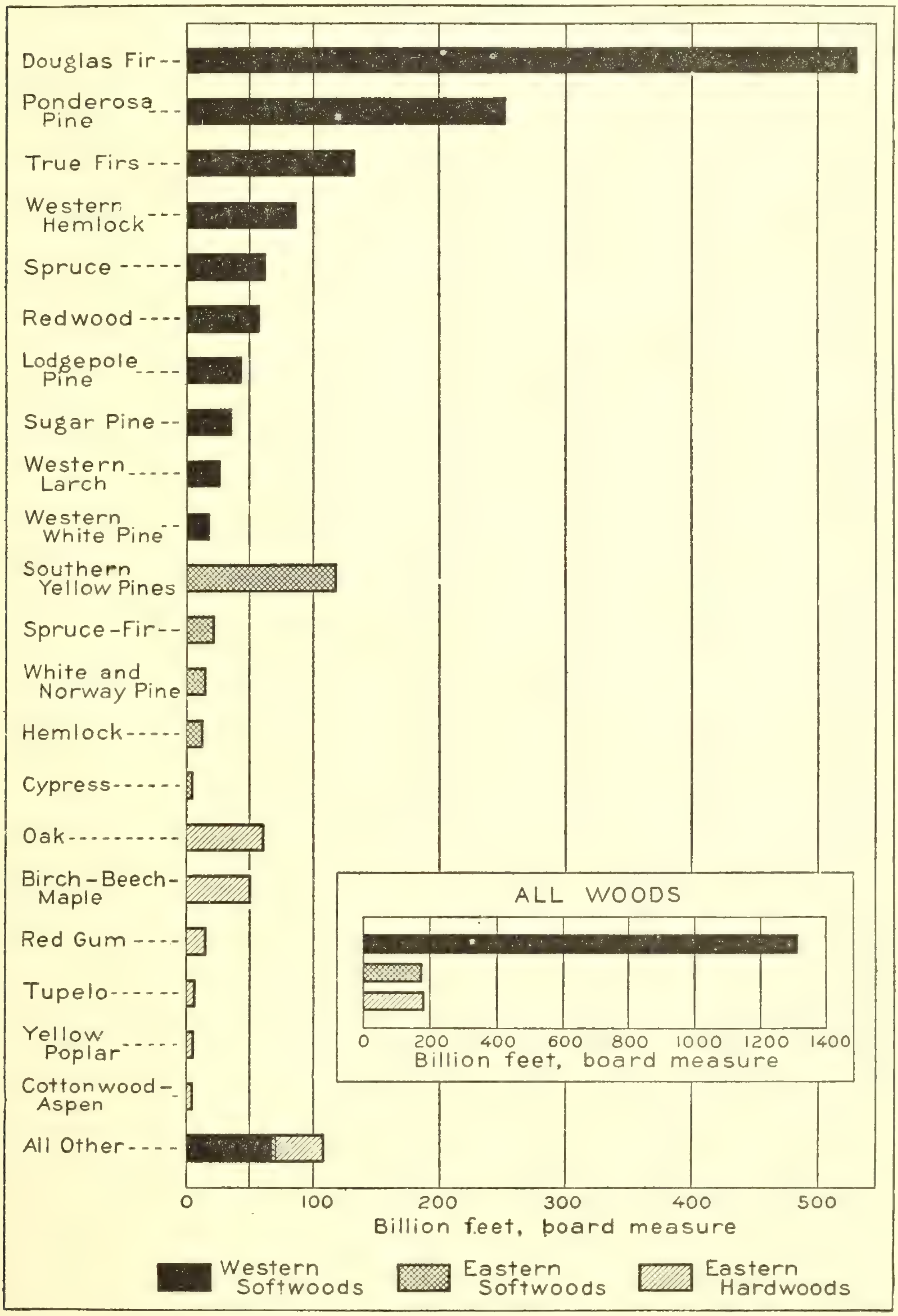

FIGURE 5.—Saw-timber stand of the United States by important woods.

In other words, the one great remaining reservoir of saw timber, and that softwood, is the Pacific Coast region. For years the New England, Middle Atlantic, Central, and Lake regions have contributed relatively little to the softwood-lumber production of the country; and the South, because of waning supplies, is losing the commanding position which it has held for 20 or 30 years. This large Pacific Coast supply of saw timber seems capable of being an important asset in helping to tide over the interval which apparently must elapse before the East can be organized on a more satisfactory forest-producing basis. Highly developed mass production methods of lumber manufacture and low-cost water transportation render much of this timber economically available to eastern consuming centers, and apparently should facilitate a period of reduced cutting and of rehabilitation of the depleted eastern softwood forests. On the other hand, owing to circumstances which need not be discussed here, the pressure to liquidate is so great upon private owners in the Pacific Coast region that stumpage is being thrown on the market with little regard to sustained yield requirements, and with the effect of further depressing market conditions, and for the time being, rendering forestry measures less attractive for the private forest-land owners in other regions.

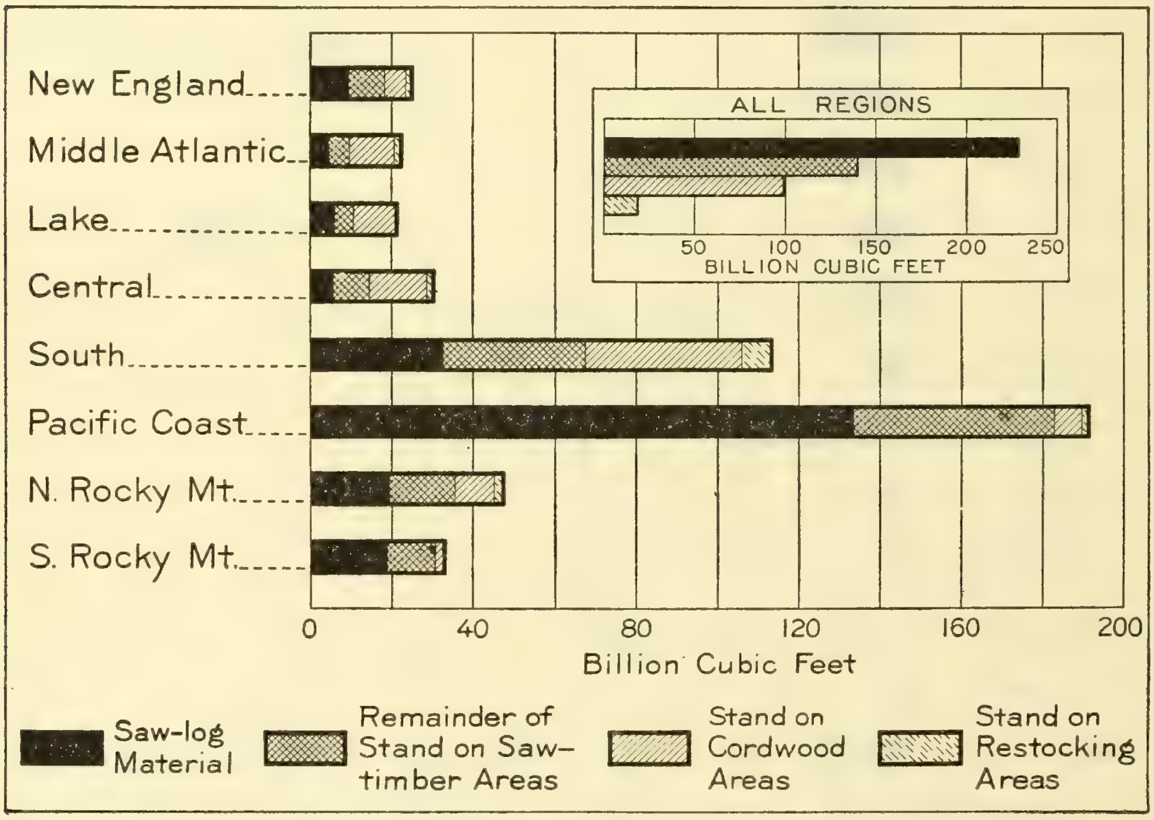

FIGURE 6.—Total stand (cubic feet) in the United States including saw-timber areas, cordwood areas, and restocking areas, by regions.

Table 2 and figure 5 illustrate the distribution of the saw timber by hardwoods and softwoods, and by important species, for eastern and western United States. Douglas fir, with 530 billion board feet, 80 percent of which is in Washington and Oregon, is far in the lead. Ponderosa pine, widely distributed through the West, is second with 252 billion. These two species comprise half the softwood saw timber of the entire country.

TABLE 2.—*Stand of saw timber in the United States, by region and species*

[In million feet board measure]

Kind of wood	Total	New England	Middle Atlantic	Lake	Central	South	Pacific Coast	North Rocky Mountain	South Rocky Mountain
Eastern hardwoods:									
Oak	60,753	1,048	4,783	6,017	16,315	32,590	-----	-----	-----
Birch, beech, and maple	49,943	20,973	8,555	13,459	4,401	2,555	-----	-----	-----
Red gum	15,488	-----	71	-----	874	14,543	-----	-----	-----
Tupelo	6,342	-----	-----	-----	116	6,226	-----	-----	-----
Yellow poplar	5,172	18	203	-----	1,635	3,316	-----	-----	-----
Cottonwood and aspen	4,437	2,022	20	887	222	1,286	-----	-----	-----
Others	37,098	1,003	4,273	6,331	8,159	17,332	-----	-----	-----
Total	179,233	25,064	17,905	26,694	31,722	77,848	-----	-----	-----
Eastern softwoods:									
Southern yellow pine	118,132	-----	597	-----	1,433	116,102	-----	-----	-----
Spruce and fir	21,533	18,720	1,564	843	175	231	-----	-----	-----
White and Norway pine	14,672	8,390	3,530	2,392	159	201	-----	-----	-----
Hemlock	12,198	3,675	2,462	4,612	765	684	-----	-----	-----
Cypress	4,140	-----	-----	-----	263	3,877	-----	-----	-----
Others	3,923	2,026	92	1,346	105	354	-----	-----	-----
Total	174,598	32,811	8,245	9,193	2,900	121,449	-----	-----	-----
Western hardwoods	2,720	-----	-----	-----	-----	-----	2,719	-----	1
Western softwoods:									
Douglas fir	530,197	-----	-----	-----	-----	-----	484,138	33,933	12,126
Ponderosa pine	251,560	-----	-----	-----	-----	-----	178,051	31,938	41,571
True fir	131,933	-----	-----	-----	-----	-----	109,196	14,594	8,143
Western hemlock	86,464	-----	-----	-----	-----	-----	86,464	-----	-----
Spruce	61,582	-----	-----	-----	-----	-----	12,782	12,513	36,287
Redwood	57,233	-----	-----	-----	-----	-----	57,233	-----	-----
Lodgepole pine	43,276	-----	-----	-----	-----	-----	2,143	14,556	26,577
Sugar pine	35,516	-----	-----	-----	-----	-----	35,516	-----	-----
Western larch	26,118	-----	-----	-----	-----	-----	8,043	18,075	-----
Western white pine	19,508	-----	-----	-----	-----	-----	3,944	15,564	-----
Others	67,865	-----	-----	-----	-----	-----	61,399	5,215	1,251
Total	1,311,252	-----	-----	-----	-----	-----	1,038,909	146,388	125,955
All species	1,667,803	57,875	26,150	35,887	34,622	199,297	1,041,628	146,388	125,956

The true firs of the West comprise 132 billion, and then come the southern yellow pines, including principally longleaf, loblolly, shortleaf, and slash pine, with 118 billion. The once large supply of northern white pine in the Lake States, highly prized as a standard wood for millwork, boxes and crates, novelties, and patterns, has been so depleted that it now comprises less than 1 percent of the country's softwood. Western white pine and sugar pine, however, are substantially similar to the white pine of the East in technical and mechanical characteristics, but the supply of these is also small.

The hardwoods are practically confined to the East. They constitute but one tenth of the country's saw-timber stand, and yet contribute annually a quarter of the saw-timber cut. Unlike the softwood stands, in which second growth makes up but one seventh of the total, hardwood stands comprise nearly twice as much second growth as old growth. The South is the most important hardwood region with 43 percent of the total hardwood stand for the country.

We are approaching measurably near the end of our ready-grown mature hardwoods. Depletion of the hardwood supply has not only progressed further than that of softwoods, but this progress is particularly marked among the more valuable woods (table 2 and fig. 5). Three of the most valuable hardwoods—hickory, ash, and yellow poplar—together have an estimated stand of less than 15 billion.

CORDWOOD

The total volume of all classes of cordwood is estimated to be 2,382 million cords. This total includes trees too small for saw logs but large enough for cordwood use, regardless of whether it is cut for cordwood or held for saw timber. It is made up of (1) the material on the cordwood areas, estimated at 1,102 million cords, and (2) the material below saw-timber size on saw-timber areas, estimated at 1,280 million cords. The latter, in turn, is made up of 794 million cords of small trees and 486 million cords of tops and limbs (tops only in softwoods) of saw-timber trees.

TABLE 3.—*Stand of cordwood on cordwood and saw-timber areas of the United States, by regions*

[In thousands of cords]

Region	Total		Cordwood areas			Saw-timber areas		
			Total	Soft-wood	Hard-wood	Total	Soft-wood	Hard-wood
		Per cent						
New England	149, 913	6	56, 801	14, 555	42, 246	93, 112	20, 238	72, 874
Middle Atlantic	179, 002	8	125, 641	15, 873	109, 768	53, 361	11, 154	42, 207
Lake	170, 690	7	123, 398	37, 207	86, 191	47, 292	10, 400	36, 892
Central	252, 273	11	156, 338	10, 720	145, 618	95, 935	5, 455	90, 480
South	792, 339	33	429, 900	262, 959	166, 941	362, 439	181, 797	180, 642
Pacific Coast	429, 863	18	75, 906	75, 386	520	353, 957	353, 131	826
North Rocky Mountain	263, 212	11	104, 604	104, 604	--------	158, 608	158, 608	--------
South Rocky Mountain	144, 805	6	29, 555	29, 282	273	115, 250	115, 250	--------
Total	2, 382, 097	100	1, 102, 143	550, 586	551, 557	1, 279, 954	856, 033	423, 921

Table 3 gives the regional estimates for softwoods and hardwoods on cordwood and saw-timber areas. The volume on cordwood areas is almost exactly divided between hardwoods and softwoods. Two thirds of the total volume, including practically all of the hardwoods, is in the East, where are the vastly greater cordwood areas.

In many instances cordwood stands may properly be handled on short rotation, for such products as pulpwood, fence posts, fuel wood, etc., or where some necessity enters in to make the cutting of the young stand both desirable and profitable. On the whole, however, the primary function of the stands on cordwood areas should be to serve as essential forest capital or growing stock, to be developed into saw timber rather than to be cut as cordwood. This statement is predicated on the belief that, broadly speaking, and in the light of present knowledge, the bulk of our forests should be managed primarily to produce saw timber, both to obtain the greatest return on the investment and at the same time to meet most adequately future timber requirements. To accomplish this, however, something better than the present average of nine cords per acre should be present. The indication is that the majority of cordwood areas are subnormally stocked and that they need building up if the future forest is to be adequately productive.

The trees below saw-log size, on a large proportion of the saw-timber area (table 4) should be considered as growing stock rather than as timber available for harvesting. Over a third of the total possible cordwood supply on saw-timber areas is estimated to be in the form of tops and limbs of saw-timber trees. As a means of preserving growing stock and conserving waste, it is highly desirable that this material should be utilized up to the measure of present feasible and economical woods practice. Leaving this material in the woods to burn or rot, according to present general practice, represents far more than the mere loss of so much raw material. Progress in utilizing such material will not only have the practical effect of increasing the country's wood supply; it will facilitate fire prevention and control, curb somewhat the tendency toward the too-early cutting of promising saw timber, and leave the land in better condition for restocking.

TABLE 4.—*Stand of cordwood on saw-timber areas in the United States, by type of material and region*

Region	Total		Small trees [1]			Tops and limbs [2]		
			Total	Softwood	Hard-wood	Total	Softwood	Hard-wood
	Thousand cords	*Per-cent*	*Thousand cords*	*Thousand cords*	*Thousand cords*	*Thousand cords*	*Thousand cords*	*Thousand cords*
New England	93, 112	7	69, 872	12, 036	57, 836	23, 240	8, 202	15, 038
Middle Atlantic	53, 361	4	40, 556	9, 095	31, 461	12, 805	2, 059	10, 746
Lake	47, 292	4	28, 855	8, 103	20, 752	18, 437	2, 297	16, 140
Central	95, 935	8	75, 114	4, 730	70, 384	20, 821	725	20, 096
South	362, 439	28	280, 104	151, 436	128, 668	82, 335	30, 361	51, 974
Pacific Coast	353, 957	28	103, 179	102, 897	282	250, 778	250, 234	544
North Rocky Mountain	158, 608	12	120, 264	120, 264	----------	38, 344	38, 344	----------
South Rocky Mountain	115, 250	9	76, 243	76, 243	----------	39, 007	39, 007	----------
Total	1, 279, 954	100	794, 187	484, 804	309, 383	485, 767	371, 229	114, 538

[1] Less than saw-timber size but large enough for cordwood.

[2] Of saw-timber trees; only the tops in the case of softwoods.

One effective way for reducing and utilizing not only logging waste but also wood waste in general is to be found in the integration of a variety of wood-using industries, either under one ownership or around an industrial wood-using center. Such a set-up results in the utilization of large volumes of the different forms of wood waste, and in turn permits of the specialization required in the manufacture of diverse mechanical and chemical products. Also, improved logging, manufacturing, and marketing methods doubtless can be developed. Research can aid in all these things, especially in improving the usefulness of wood as wood, and in creating new chemical and other products derived from wood.

In brief, requirements for cordwood material ordinarily should not be allowed to impair the growing stock on either saw-timber or cordwood areas, but should be satisfied, first, with as complete utilization as is practicable of tops and limbs on saw-timber areas; and, second, by improvement cuttings on areas where growth of the remaining stand can thereby be increased. Beyond this, and certain obviously exceptional instances where the only economical and reasonable course is a cordwood rotation, the emphasis should consistently be placed on the development of cordwood into saw-timber stands.

PULPWOOD

Pulpwood supplies present a highly specialized problem involving many economic and technical complexities, some of them matters of world supply and demand. Although a satisfactory estimate of economically usable present pulpwood supplies can hardly be attempted, it may be appropriate to present some quantitative estimates of the supplies of species either now cut in quantity for pulpwood or which seem to be technically capable of use by the pulp and paper industry.

The relation of pulpwood requirements and supplies is not static. The tendency in pulp and paper manufacture as in other fields of wood utilization is toward an increasing number of species regarded as suitable, with a consequent enlargement of the volume of potential pulpwood supplies. There has been a drift toward lower requirements as to size, form, and quality of material. In some regions, notably the Pacific Coast, a large part of the pulpwood is cut from saw-timber trees, with the tops and limbs left unutilized in the woods. In other regions, such as the Lake and South, much of the pulpwood comes from cordwood stands.

Table 5 shows the gross estimate of the species more commonly used for paper pulp by regions, and for softwoods and hardwoods separately. This is presented without any implication that these supplies are anything like completely available in an economic sense either nationally or for any single region. Nor is any prediction here attempted as to what proportion may ultimately be cut for pulpwood and what for other purposes.

The 1,830 million cords thus indicated constitutes about one third of the gross volume of all commercial forest material in the United States—saw timber 860 million cords, or 47 percent; small trees on saw-timber areas 420 million cords, or 23 percent; and cordwood on cordwood areas 550 million cords, or 30 percent. Largely because of the inclusion of southern yellow pines (now used mainly for sulphate pulp) the South is shown to have two fifths of the total supply. The Pacific Coast region with only spruce, hemlock, and true fir included has one fifth. If the saw-timber stands of Douglas fir, ponderosa pine, western white pine, sugar pine, and larch—all western species potentially important for pulpwood—were included another 1,800 million cords would be added.

TABLE 5.—*Stand of principal kinds of wood now used in pulp and paper manufacture, by regions*

Kind of wood	Total [1]	New England	Middle Atlantic	Lake
	Thousand cords	*Thousand cords*	*Thousand cords*	*Thousand cords*
Softwoods:				
Spruce and fir	431, 242	45, 030	5, 931	17, 526
Hemlock	206, 825	10, 467	9, 100	12, 619
Southern yellow pine	623, 525		8, 751	
White, Norway, and jack pine	66, 404	24, 190	14, 575	25, 242
Tamarack	1, 986	14		1, 972
Total	1, 329, 982	79, 701	38, 357	57, 359
Hardwoods:				
Cottonwood and aspen	30, 463	10, 590	1, 752	10, 662
Yellow poplar	38, 702	152	3, 338	
Birch, beech, and maple	305, 404	115, 235	68, 581	74, 610
Gum	124, 694		2, 601	
Total	499, 263	125, 977	76, 272	85, 272
All species	1, 829, 245	205, 678	114, 629	142, 631

[1] Includes material suitable for saw logs, small trees on saw-timber areas, and cordwood on cordwood areas.

TABLE 5.—*Stand of principal kinds of wood now used in pulp and paper manufacture, by regions*—Continued

Kind of wood	Central	South	Pacific Coast	North Rocky Mountain	South Rocky Mountain
	Thousand cords	*Thousand cords*	*Thousand cords*	*Thousand cords*	*Thousand cords*
Softwoods:					
Spruce and fir	610	781	205, 861	[2] 48, 174	107, 329
Hemlock	3, 962	3, 883	166, 794		
Southern yellow pine	10, 453	604, 321			
White, Norway, and jack pine	848	1, 549			
Total	15, 873	610, 534	372, 655	48, 174	107, 329
Hardwoods:					
Cottonwood and aspen	1, 651	5, 535			273
Yellow poplar	12, 090	23, 122			
Birch, beech, and maple	31, 430	15, 548			
Gum	9, 070	113, 023			
Total	54, 241	157, 228			273
All species	70, 114	767, 762	372, 655	48, 174	107, 602

[2] Includes western hemlock.

Over a third of the estimated pulpwood stands, or 638 million cords, consists of spruce, fir, and hemlock—species suited for all four types of pulp, but especially desired for mechanical and sulphite pulps which make up about two thirds of our total pulp requirements. The Pacific Coast region has about 60 percent of this spruce-fir-hemlock supply. Less than a third, or 500 million cords, consists of yellow poplar, birch, beech, maple, gum, cottonwood, and aspen—eastern species used mostly for soda pulp. The remaining 692 million cords consist mostly of southern yellow, white, Norway, and jack pines—species used largely for sulphate pulp.

TOTAL VOLUME OF TIMBER

Volumes in terms of cubic feet afford the only practical basis for measuring the total volume of timber and for comparing directly the total volume of timber with the total volume of timber growth or the total volume of timber depletion.[1] Table 6 and figure 6 furnish detailed information on the total cubic foot volumes for the several regions. Of the total volume of 487 billion cubic feet, nearly half or 229 billion cubic feet is saw-log material. The volume in small trees on saw-log areas aggregates 70 billion cubic feet, cordwood areas 100 billion, and scattered trees on restocking areas 18 billion. The volume of wood in the tops, limbs, stumps, long butts, etc., of saw-timber trees makes up the remaining 70 billion cubic feet, of which the bulk falls in the category of so-called woods waste.

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[1] It may prove misleading to compare different estimates in cubic feet of the same stand of timber, unless it is known that the same conversion factors, similarly applied, were used in each case. The present estimate in cubic feet of the total volume of timber in the United States, for example, is lower than that of the Forest Service in 1920 in the report on S. Res. 311, the difference being due in part to the use of different conversion factors but mostly to timber depletion.

TABLE 6.—*Total stand (cubic feet) of softwoods and hardwoods in the United States, including saw-timber, cordwood, and restocking areas, by type of material and region*

Region	Saw timber [1]		Small trees [2]		Tops and limbs [3]	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
	Million cubic feet	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*
New England	5,183	4,086	1,082	5,205	738	1,353
Middle Atlantic	1,302	2,918	819	2,831	185	968
Lake	1,453	4,359	729	1,867	206	1,452
Central	458	5,235	425	6,334	65	1,809
South	19,190	13,523	13,629	11,578	2,733	4,678
Pacific Coast	132,917	351	9,243	25	22,520	49
North Rocky Mountain	19,269	----------	10,824	----------	3,451	----------
South Rocky Mountain	18,815	----------	6,860	----------	3,509	----------
Total	198,587	30,472	43,611	27,840	33,407	10,309

Region	Other [4]		Cordwood and restocking areas		Total area		
	Softwood	Hardwood	Softwood	Hardwood	Total stand	Softwood	Hardwood
	Million cubic feet	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*
New England	260	286	1,835	5,202	25,230	9,098	16,132
Middle Atlantic	64	204	1,661	11,697	22,649	4,031	18,618
Lake	73	305	3,349	7,757	21,550	5,810	15,740
Central	22	366	1,110	14,832	30,656	2,080	28,576
South	960	947	28,451	18,122	113,811	64,963	48,848
Pacific Coast	17,540	56	8,956	75	191,732	191,176	556
North Rocky Mountain	2,076	----------	12,148	----------	47,768	47,768	----------
South Rocky Mountain	1,465	----------	2,650	24	33,323	33,299	24
Total	22,460	2,164	60,160	57,709	486,719	358,225	128,494

[1] Only the portion of tree suitable for saw logs, saw-timber area.
[2] Less than saw-timber size but large enough for cordwood, saw-timber area.
[3] Of saw-timber trees; only the tops in the case of softwoods.
[4] Stumps, long butts, and breakage, saw-timber area.

The preponderant position of the Pacific Coast region stands out with respect to total volume in much the same manner, although not so strikingly as in connection with saw-log volume. A main reason, of course, is the great amount of virgin saw timber in the Pacific Coast, but another reason is the extremely depleted growing stock or forest capital in the East, generally speaking. The Pacific Coast region with 13 percent of the total forest area contains 40 percent of the total timber volume and nearly 60 percent of the saw timber. At the other extreme, the Lake region with nearly as much land contains less than 5 percent of the total timber volume and only about 2 percent of the saw timber. The South, in an intermediate position, with 40 percent of the forest area contains only 25 percent of the total volume and 14 percent of the saw timber.

OWNERSHIP OF TIMBER SUPPLIES

Forest-land ownership has been discussed and the importance of its character has been emphasized in the section, "Forest Land the Basic Resource." Of corresponding importance is the nature of the ownership of the standing timber. It bears upon the time and rapidity of cutting in respect both to market conditions and to organization for sustained yield regionally and nationally. It influences the care with which the timber is utilized. And finally, and very importantly, it influences the character of the cutting, the care that is exercised and the measures taken before, during, and after cutting to insure the establishment and protection of restocking—the sine qua non to keeping forest lands continuously productive. These matters are so closely related to the ownership of the forest land that reference to the discussion of that subject should be made. The brief discussion of timber stand ownership at this point should be regarded as supplemental to that of lands.

TABLE 7.—*Ownership of stands of saw timber in the United States, by regions*

Region	All stands		Federally owned or managed			
			Total	National forest	Indian reservation	Other
	Million ft. b. m.	*Per cent*	*Million ft. b. m.*	*Million ft. b. m.*	*Million ft. b. m.*	*Million ft. b. m.*
New England	57,875	3	1,119	1,119	----------	----------
Middle Atlantic	26,150	2	98	94	----------	4
Lake	35,887	2	2,284	1,200	1,084	----------
Central	34,622	2	449	444	----------	5
South	199,297	12	3,868	3,653	195	20
Pacific Coast	1,041,628	62	421,571	357,198	21,342	43,031
North Rocky Mountain	146,388	9	93,130	88,840	2,290	2,000
South Rocky Mountain	125,956	8	114,983	99,917	6,995	8,071
Total	1,667,803	100	637,502	552,465	31,906	53,131

Region	State, county, and municipal	Private		
		Total	Industrial	Farm woodland
	Million ft. b. m.	*Million ft. b. m.*	*Million ft. b. m.*	*Million ft. b. m.*
New England	1,363	55,393	47,421	7,972
Middle Atlantic	221	25,831	13,831	12,000
Lake	870	32,733	21,771	10,962
Central	107	34,066	16,613	17,453
South	312	195,117	146,850	48,267
Pacific Coast	26,155	593,902	568,696	25,206
North Rocky Mountain	11,527	41,731	40,223	1,508
South Rocky Mountain	1,457	9,516	9,452	64
Total	42,012	988,289	864,857	123,432

SAW TIMBER

Ownership of saw timber is of special importance, because premature or untimely liquidation of saw timber especially, upsets market conditions for forest products, with results that lead the industrial forest owner to seriously doubt the wisdom or the economic soundness of forestry for him. The comparatively long rotations incident to saw timber production add to the complexities of management. It is in connection with saw timber also that the problems of wise allocation of cut for sustained yield organization of forest lands, regionally and nationally, chiefly reside.

Table 7 and figure 7 present the United States regional and total distribution of saw timber for industrial, farm woodland, and public ownership. Industrial ownership includes ownership by land, lumber, pulp and paper, and mining companies, naval stores operators, railroads, and miscellaneous individuals or agencies. According to these estimates, 865 billion board feet, or 52 percent of the saw timber stand, is industrially owned. This corresponds fairly closely with the 48 percent of the saw-timber area thus owned. By and large it includes the best and most accessible saw timber. Sixty-six percent of all this industrial saw timber is in the Pacific Coast region. Chiefly in this timber are the problems which involve precipitate liquidation, with all its demoralizing influence not only upon the market but for the time being upon private forestry practice in the eastern United States. This ownership class contains a notably larger proportion of saw-timber volume than of area in the Pacific Coast region, as would naturally follow from the fact that in that region the better stands are industrially owned. The percentages are 55 and 39 respectively.

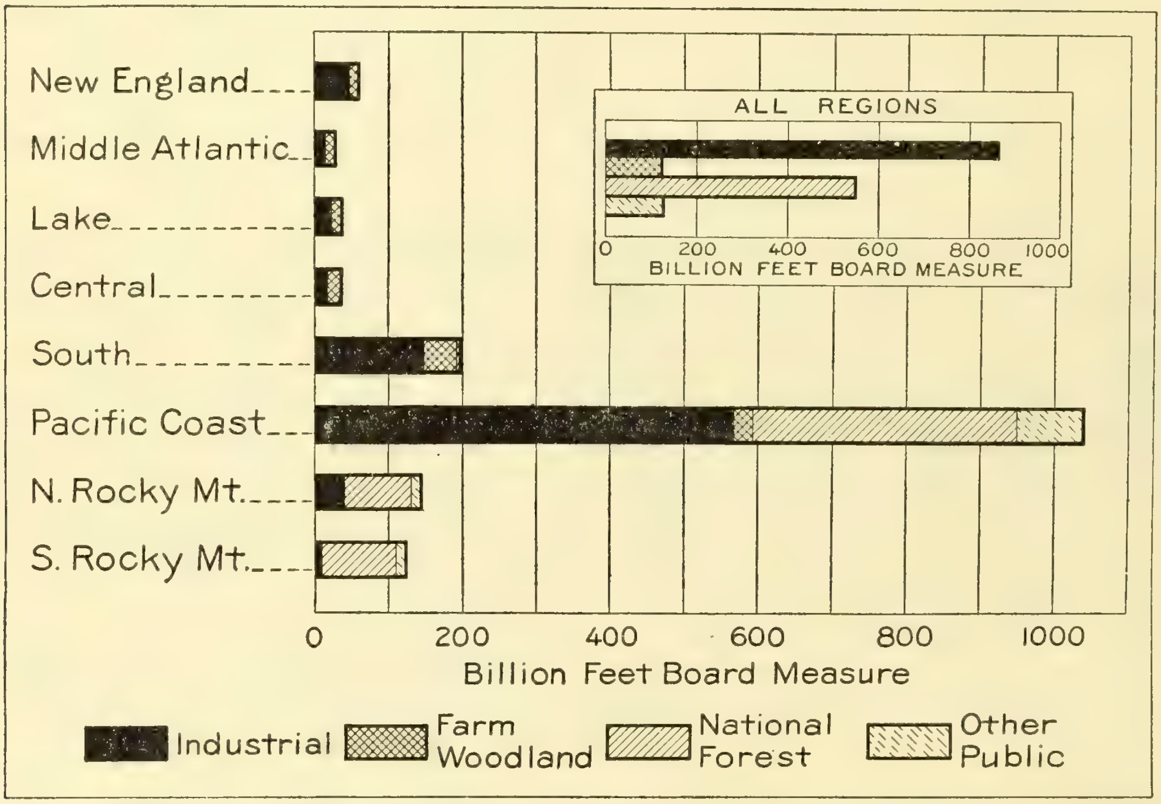

FIGURE 7.—Ownership of saw-timber stand of the United States by regions.

Farm woodlands include 123 billion board feet or 7 percent of the total saw-timber stand. With a relatively stable ownership, except on submarginal farms, and more subject to something like a rough selection system of cutting, they present less critical problems than do the industrial saw-timber stands, generally.

Public ownership includes the remaining 680 billion board feet, or 41 percent of the saw-timber stands. It includes a larger proportion of relatively inaccessible timber in the West. Although the stand per acre is less than for industrial ownership in the West, the proportion of saw-timber stands in public ownership in all regions is somewhat in excess of the corresponding 33 percent of the area of the country as a whole. By the nature of the case, public ownership of saw timber for the most part is committed to a conservative policy of cutting designed to place stumpage on the market only when consistent with economic conditions and the dictates of sound forestry.

Of the publicly owned or managed saw timber 552 billion board feet or 81 percent is included in the national forests, 41 billion is involved in the Oregon and California land grants, and about 32 billion board feet is administered by the Indian Service. States, counties, and municipalities together hold 42 billion board feet, of which the portion held by counties and municipalities is less than half a billion board feet.

There is a dearth of publicly owned or managed saw timber in the East, where it amounts to only 11 out of 680 billion board feet. This in itself emphasizes the desirability of considering an expanded program of public forest and forest land ownership in the East.

An examination of the details as to relative saw-timber stand conditions for the different ownerships emphasizes again that the national situation is a complex of widely varying regional conditions, each so much affected by peculiar local factors that it is unsafe to go very far in drawing general conclusions. Table 8 shows the stand per acre on an ownership basis for groups of regions within which conditions are roughly comparable. Not only are the stands for the Pacific Coast much heavier in general than the average for the rest of the country but they are much heavier than those of any other single region. Within the Pacific Coast region the industrially owned old-growth is more than twice as heavy per acre as that on farm woodlands and publicly owned. This emphasizes again the fact that industrial ownership, by and large, includes the best of the saw timber.

TABLE 8.—*Average stand of saw timber per acre, by class of ownership, region, and character of growth*

Region	Industrial			Farm woodland			Public		
	Area	Total stand	Stand per acre	Area	Total stand	Stand per acre	Area	Total stand	Stand per acre
	Thousand acres	*Million ft.b.m.*	*Feet b.m.*	*Thousand acres*	*Million ft.b.m.*	*Feet b.m.*	*Thousand acres*	*Million ft.b.m.*	*Feet b.m.*
Pacific Coast region:									
Old growth	14, 804	532, 991	36, 003	1, 032	16, 229	15, 726	23, 056	409, 409	17, 757
Second growth	2, 363	35, 705	15, 110	708	8, 977	12, 679	2, 177	38, 317	17, 601
Total	17, 167	568, 696	33, 127	1, 740	25, 206	14, 486	25, 233	447, 726	17, 744
Rocky Mountain regions:[1]									
Old growth	4, 601	47, 316	10, 284	211	943	4, 469	28, 483	210, 637	7, 395
Second growth	1, 333	2, 359	1, 770	187	629	3, 364	4, 952	10, 460	2, 112
Total	5, 934	49, 675	8, 371	398	1, 572	3, 950	33, 435	221, 097	6, 613
Eastern regions:[2]									
Old growth	22, 241	107, 394	4, 829	2, 192	13, 351	6, 091	2, 235	7, 505	3, 358
Second growth	45, 210	139, 092	3, 077	31, 383	83, 303	2, 654	1, 477	3, 186	2, 157
Total	67, 451	246, 486	3, 654	33, 575	96, 654	2, 879	3, 712	10, 691	2, 880
All regions:									
Old growth	41, 646	687, 701	16, 513	3, 435	30, 523	8, 886	53, 774	627, 551	11, 670
Second growth	48, 906	177, 156	3, 622	32, 278	92, 909	2, 878	8, 606	51, 963	6, 038
Aggregate	90, 552	864, 857	9, 551	35, 713	123, 432	3, 456	62, 380	679, 514	10, 893

[1] North and South Rocky Mountains.
[2] New England, Middle Atlantic, Lake, Central, and South.

The relatively low averages for farm woodland are doubtless in part due to the very small proportion of old growth as well as to the typically more selective character of the farm woodland saw timber resulting from partial cutting at shorter intervals.

CORDWOOD

Table 9 and figure 8 supply information as to the regional and United States distribution by ownership of cordwood on cordwood areas. Fifty-two percent of this cordwood is industrially owned, 32 percent is in farm woodland, and but 16 percent is publicly owned. As would be expected, the percentage in farm woodland is much larger, and that in public much smaller, than the corresponding percentages for saw timber. And, of course, owing to the vastly greater areas of this type of stand in the East, the proportions of it in all ownerships are very much greater than for saw timber. The industrial and farm woodland cordwood volumes of the South are far in excess of those of any other region.

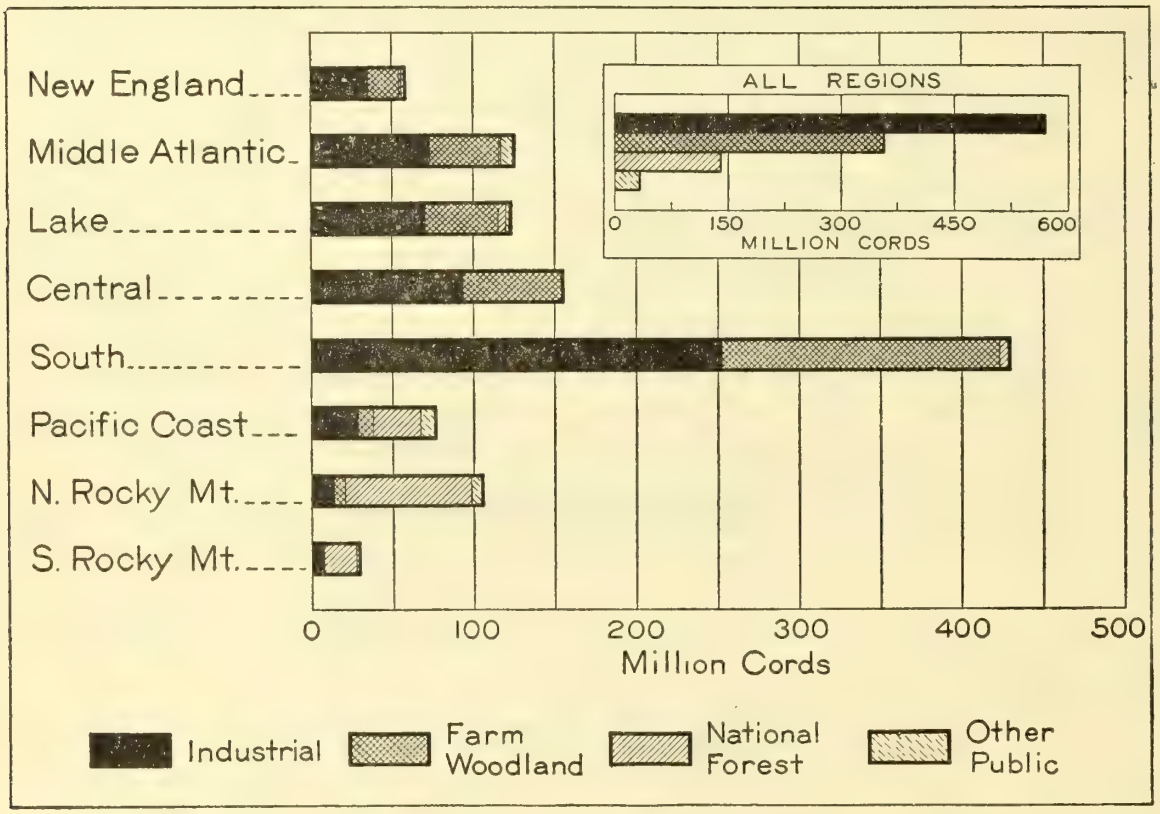

FIGURE 8.—Ownership of stand of cordwood on cordwood areas by regions.

TABLE 9.—*Ownership of stands of cordwood on cordwood areas in the United States, by regions*

Region	All stands		Federally owned or managed			
			Total	National forest	Indian reservation	Other
	Thousand cords	*Percent*	*Thousand cords*	*Thousand cords*	*Thousand cords*	*Thousand cords*
New England	56,801	5	1,253	1,253		
Middle Atlantic	125,641	11	718	608		110
Lake	123,398	11	5,197	4,633	564	
Central	156,338	14	743	743		
South	429,900	39	6,018	5,963	30	25
Pacific Coast	75,906	7	37,155	28,700	2,869	5,586
North Rocky Mountain	104,604	10	83,402	78,871	2,240	2,291
South Rocky Mountain	29,555	3	22,324	20,755	799	770
Total	1,102,143	100	156,810	141,526	6,502	8,782

TABLE 9.—*Ownership of stands of cordwood on cordwood areas in the United States, by regions*—Continued

Region	State, county, and municipal	Private		
		Total	Industrial	Farm woodland
	Thousand cords	*Thousand cords*	*Thousand cords*	*Thousand cords*
New England	2, 098	53, 450	33, 845	19, 605
Middle Atlantic	8, 794	116, 129	73, 225	42, 904
Lake	2, 726	115, 475	69, 970	45, 505
Central	353	155, 242	93, 932	61, 310
South	269	423, 613	251, 666	171, 947
Pacific Coast	1, 740	37, 011	27, 582	9, 429
North Rocky Mountain	2, 152	19, 050	13, 025	6, 025
South Rocky Mountain	482	6, 749	6, 732	17
Total	18, 614	926, 719	569, 977	356, 742

AVAILABILITY OF TIMBER STANDS

The statistics for timber stands given in the preceding discussion are by no means to be interpreted as measuring the quantity of timber supplies available for cutting. Two major considerations materially reduce these stand figures when they are expressed in terms of available supply. One consideration is the necessity for maintaining a growing stock or forest capital consistent with the sustained yield of forest products to be obtained. The higher the rotation age the larger the volume of this growing stock must be. If, for example, saw timber is the object of management the growing stock must be greater than it would be if pulpwood and other small material only are to be grown. If, as is the case with most of the eastern regions, the growing stock is already too small it should be built up. Cutting, then, should be restricted to improvement operations, except as the presence of mature stands may require a more extensive cut, or pressing social or economic conditions of the locality concerned may justify the sacrifice of future yields. This growing stock relationship to available supplies will be further discussed in the subsection on Timber Growth.

The second major consideration is that of economic availability. After the requirements of adequate growing stock have been satisfied, or even where they are not, there is still the question whether a particular stand can be cut now or prospectively with a profit or at least without financial loss. Economic availability depends upon such things as volume of timber per acre, its size and quality, the proportion of inferior species, logging difficulties, length of haul to mill, the cost of milling and of getting the manufactured product to market, and the price that can be obtained for the product.

There is but little thoroughly reliable information on present economic availability. Such information as there is, however, warrants the broad judgment that but little more than half of the estimated 1,668 billion board feet of saw timber in the United States can be cut profitably on the basis of the operating costs and mill lumber prices of recent years (fig. 9), or would on this basis have a positive conversion value.

The limits of economic availability are ever changing. As the more accessible and desirable stands have been cut out, logging and milling practices have, from the standpoint of engineering and mechanics, become much more efficient. It has become, therefore, increasingly feasible to log more remote areas. At the same time, knowledge of the adaptability of the less desirable species for special purposes has grown and the trend has been toward the utilization of the less desirable species. In view of such developments, it would be unsafe to prophesy as to the proportion of existing timber stands that may ultimately prove to be economically available. It seems reasonable to believe, however, that competing or substitute materials for wood, which already have become a powerful factor, will prevent the indefinite pushing back of the limits of availability.

REGIONAL AVAILABILITY OF SAW TIMBER

The economic availability of saw timber, as estimated very roughly by regions, will give concrete evidence of the wide divergence that may exist between stand and availability in any estimate of national timber supply.

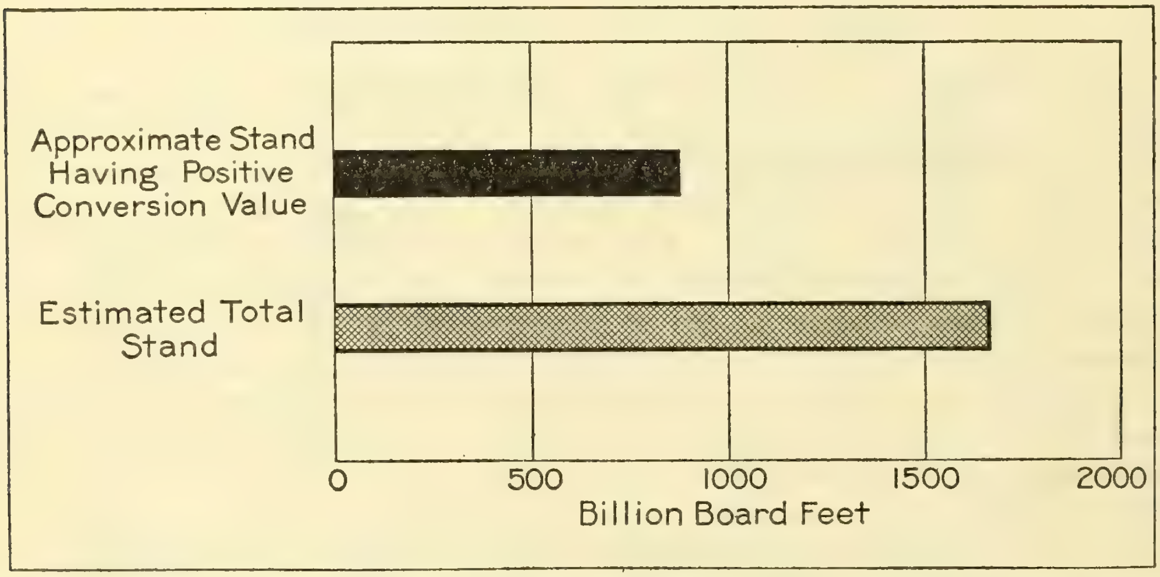

FIGURE 9.—Approximate stand of saw timber in the United States having a positive conversion value on the basis of 1925–29 lumber prices (mill) and operating conditions, in comparison with total saw-timber stand.

NEW ENGLAND, MIDDLE ATLANTIC, LAKE, AND CENTRAL REGIONS

The combined saw-timber stand of these four regions amounts to about 155 billion board feet or less than one tenth of the national supply. Hardwoods make up two thirds of the total. Old-growth saw timber comprises less than 60 billion board feet. The bulk of it is confined to the more remote and sparsely settled sections with poor transportation facilities. Many of these old-growth stands have been so heavily culled that the remaining overmature and defective timber cannot be marketed profitably. The fact that there are any old-growth stands left in these four regions, which contain 67 percent of the population of the United States, but furnish only 15 percent of the total lumber cut, indicates that the bulk are relatively inaccessible, scattered, or of poor quality.

Much of the second-growth saw timber, largely as the result of fires and of cullings for the more desirable timber, consists of little more than scattered trees that barely meet the minimum requirements for saw logs, in mixture with badly defective trees or those of less desirable species. In short, these stands have progressively deteriorated. In the main, they can supply little but common lumber, and a considerable proportion cannot be cut at a profit.

SOUTH REGION

The saw-timber stands of the South, which aggregate some 200 billion board feet, are in general more accessible and of better quality than those of the other four eastern forest regions. The large lumber cut of the region alone would indicate this. The South until recently has produced from 15 to 17 billion board feet of lumber annually, or not far from half of the softwood and of the hardwood lumber production of the entire country.

Much of the 121 billion board feet of softwood in the South is found in the coastal plain from Virginia to Texas, with the bulk of the remainder either on the bluffs and uplands east of the Mississippi River or on the rocky hills of central Alabama, west central Arkansas, and southeastern Oklahoma. The flat coastal plain is uniformly one of the cheapest in the United States for logging operations. Except for limited areas in the mountains and swamps the entire South presents few difficulties in logging.

Less than one third of the softwood saw timber, however, is old growth. The bulk of the original forests has been cut since 1890. Largely because of uncontrolled fires and the absence of seed trees, large areas were slow to restock. Cutting and destructive turpentining have further tended to limit the size and quality of the second-growth saw timber. Not only is much of the second growth comparatively young and therefore barely of saw-log proportions, but it is frequently found on small, scattered areas. Young second growth, of course, will not, as a rule, yield the strong and durable structural timber, fine-grained and wide finish, or the other better grades of lumber that are now cut from large, mature trees. Nevertheless, a large lumber cut is now coming from small, low-grade second growth. Although cutting of this small second growth for lumber is thought to be unwise, because the trees are not financially mature, it may be said, from the standpoint of accessibility only, that substantially all of the second-growth softwood saw timber of the South can be classed as available supplies.

The hardwoods in the South aggregate nearly 80 billion board feet, as compared with the annual cut in that region of 7½ billion. Old-growth accounts for only 33 billion feet. A substantial proportion of the hardwood stands cannot at present be utilized profitably for lumber, veneer, and similar products. Some of the stands, for example, are far distant from transportation facilities or considerably isolated by cut-over areas. Others contain large numbers of small, inferior, or defective trees.

Some 35 billion feet of hardwoods is located in that portion of the southern Appalachians within the region, the piedmont plateau, and the uplands of Arkansas, Mississippi, eastern Texas, and Oklahoma. The situation in the southern Appalachians and piedmont plateau is fairly typical of the upland forests. After many years of cutting, the once heavy original forests are nearing the end. Declining supplies, together with changing market conditions, have brought about repeated and progressively heavier cullings of the remaining stands.

Forest fires, insects, and chestnut blight have also taken their toll. Until recent years, however, enough was left to make possible the relogging of areas already cut over, especially as the market for pulpwood and tanning-extract wood enabled the utilization of small timber and previously worthless species. Of late, large numbers of portable mills, as in the softwood forests, have operated on cut-over or culled lands, cleaning up the remaining saw-log and tie timber. While there still remain in the mountains a number of large old-growth tracts, as well as many promising second-growth stands, much of the hardwood timber supply is either relatively inaccessible or of poor quality. The farm woodlands which dot the valleys and plateau consist for the most part of small tracts which have been cut over several times. They, however, are more accessible than the mountain timber.

About 45 billion board feet, including the better and more accessible hardwood stands, occurs in the bottomlands and swamps of the coastal plain and lower Mississippi Valley. Approximately 30 billion of this, of which more than one third is old growth, is in the wide river bottoms of Arkansas, Louisiana, and Mississippi. Exploitation in the lower Mississippi Valley has progressed steadily since 1900; the factories of the Carolinas, the Ohio Valley, and the Lake States, once regionally independent, have been drawing on the lower Mississippi Valley hardwoods. In 1929, about one fourth of the total hardwood lumber cut of the United States came from Arkansas, Louisiana, and Mississippi. At the present rate of cutting the virgin stands of the lower Mississippi Valley will be cut out in a few years. However, second-growth and old-field stands are supplying an increasingly large percentage of the hardwood cut.

Conditions in Louisiana, the leading hardwood lumber producer, are in many respects typical of the lower Mississippi Valley. That State in 1928 had about 80 hardwood mills each with a daily output of 30,000 board feet or more. A survey of 60 mills (made cooperatively by the State of Louisiana and the Forest Service) revealed 5 mills with 10 to 15 years' supply of timber, 6 with 5 to 10 years' supply, 32 with 1 to 5 years' supply, and 17 with no timber but operating on logs bought in the vicinity of the mills. Although the available supplies may have been underestimated, indications point to a marked downward trend in merchantable hardwood timber supplies in the State.

WESTERN REGIONS

It has already been shown that 1,314 billion of the country's total saw-timber stand of 1,688 billion board feet is in the West. Much of it is high up in the mountains where logging is very costly. On the other hand, highly developed mass production methods in woods and mill, combined with rail and water transportation, have rendered the better and more accessible of these stands readily available to the far distant central and eastern markets. Just what proportion of the western timber should be considered available to the country generally is problematical. It depends to a large extent, of course, upon how much the large and distant markets will pay.

It is estimated that about 600 billion board feet, or somewhat less than half of the western supply, would have a positive realization value on the basis of the logging and milling methods and costs and of lumber prices that obtained during the 1925–29 period; or in other words, would be classed as economically available on that basis. Further improvements in logging and milling practices resulting in lower costs, or enhancement in lumber prices would automatically make more of the western timber available. Undoubtedly there will continue to be changes of this character. Howver, some forest engineers believe that large volumes can never be economically utilized.

THE MIGRATION OF FOREST INDUSTRIES

While the migratory habits of our forest industries can be explained partly by expanding markets, they are largely the result of the exhaustion of local timber supplies—a situation which sustained yield management of the regional forest resources would have largely obviated. The various migrations of the forest industries throw considerable light on present available forest supplies. The following salient facts are given for a few representative industries.

LUMBER INDUSTRY

In softwood lumber manufacture, the depletion of available virgin timber supplies has marked an industrial cycle in each forest region. Local industries developed, dominated the consuming markets of the country, and declined at last so far as to be unable to meet even the regional requirements. This cycle has been characterized by a transition from light culling to clean cutting of good timber and poor alike, and by a shift from the more to the less desirable species. The peak of softwood lumber production moved successively from New England to New York, to Pennsylvania, and thence to the Lake States. It culminated in the Lake region in the early nineties with a lumber cut of about 9 billion board feet, or about one half of the softwood cut of the entire country.

In their turn, the South and the Pacific coast regions have held the commanding position. Southern softwood lumber passed a peak of 16 billion board feet in 1909. For over a decade Pacific coast lumber has dominated Lake States markets and has now entered in appreciable quantities the markets of the South. In 1929, Washington, Oregon, California, and Idaho together produced over 15 billion feet of lumber, or about half of the total softwood lumber cut of the country in that year.

Hardwood lumber production centers have shifted in much the same way. The industry began early in New England and along the Atlantic coast, spread slowly westward through New York and Pennsylvania as the better and more accessible local supplies were cut out, and became important in Ohio and the other Central States after water and rail transportation was developed. From there it spread north into the Lake States and south into Kentucky and Tennessee and the southern Appalachian Mountains. After successively depleting the available virgin stands of these various regions, the industry moved to the lower Mississippi Valley which embraced the largest remaining stand. Now the end of abundant virgin supplies in the lower Mississippi Valley is pretty definitely in sight. Hardwoods occur in the West only to a negligible extent.

FURNITURE INDUSTRY

The furniture industry is one of a group of highly specialized industries that are confronted by a growing scarcity of suitable raw material. These industries also began in the Northeast, where local supplies of black walnut, cherry, white oak, birch, and maple were at first ample for their exacting requirements. The approaching exhaustion of these supplies, together with widening markets, forced the industries westward. They expanded rapidly in the last quarter of the nineteenth century, drawing heavily on the magnificent virgin hardwood forests of the Lake and Central States. Massachusetts, New York, and Pennsylvania, and later southern Michigan and the lower Ohio River region, became successively important in furniture manufacture. The establishment of furniture factories in North Carolina signalized a shift from northern hardwoods to the large supply of southern hardwoods, including southern oak and red gum. Now these factories, as well as those of the North, obtain much of their raw material from the lower Mississippi Valley. With the cutting out of the virgin hardwoods in these forests, which are now comparatively remote and inaccessible, the industry will have exhausted practically its last reserve of old-growth hardwoods.

VENEER INDUSTRY

The veneer industry faces much the same situation in the production of high-grade veneers from eastern hardwoods. In the North, raw material must now be obtained from second-growth stands, at high cost and often very wastefully. The large hardwood logs practically clear of defects, from which high-grade veneers are customarily produced, can be obtained only from old-growth stands. Inevitably, therefore, the industry has turned to the South for much of its raw material. Red gum is now used in larger quantities for veneer than any other wood, imposing a heavy drain on the best-quality timber of this species. Tupelo, also a southern species, stands second in quantity used for hardwood veneers.

The last decade has been marked by a striking increase in the manufacture of softwood veneers, particularly from Douglas fir, southern yellow pine, and ponderosa pine. Such veneers are used largely for shipping containers, and for built-up stock for doors, trunks, and parts of furniture and automobiles. The large, old-growth timber of the West is especially well adapted to conversion into veneers. Douglas fir leads all other softwoods in this use, being second only to red gum in total quantity consumed. Further large expansion of the use of western softwoods for veneer may confidently be expected.

Southern yellow pine is third in the quantity of wood consumed in veneer manufacture. Southern pine veneers supply the heavy demand in the South for fruit and vegetable crates. Although the southern pines are by no means as plentiful nor as favorable for veneer production as the western softwoods, a further increase of the softwood veneer industry in the South may be expected.

The total quantity of wood used in this country for veneers has doubled in the past decade. Among native species the use of ash, birch, and oak has decreased. All others have increased.

HANDLE INDUSTRY

Handles embrace a wide range of products—from the small cheap handles made of almost any wood, to axe or rake handles which are very exacting in their requirements. High-grade ash and hickory, used for the better-class products, make up three fourths of the raw material used by the industry; no satisfactory substitute has been found for these woods. The good-quality, dense, tough ash, much preferred for handles, was formerly supplied from excellent stands in the States north of the Ohio River, but these are now largely cut out and most of the present supply must be obtained from the lower Mississippi Valley. Present supplies of hickory come mainly from the South where the greater part of the better and more accessible timber has been taken. Not only must larger areas be covered to obtain suitable material, but more and more it is becoming necessary to work into the districts remote from transportation facilities.

VEHICLES AND AGRICULTURAL IMPLEMENTS

The vehicle and agricultural implements industries, located mainly in the Middle West, compete with the handle industry for southern hickory and ash. They also compete with other wood-using industries, including furniture and veneer manufacturers, for other hardwoods. Notwithstanding the extensive substitution of metal for wood in vehicles and agricultural implements, these industries are greatly handicapped by a scarcity of suitable timber for their products.

AVAILABILITY OF PULPWOOD SUPPLIES

The statistics of total timber stand of paper pulpwood species, given in table 5, require interpretation in the light of present availability even more than the statistics on saw-timber stands. Thus it appears that for the United States as a whole the present stand of softwoods suitable for pulp is 280 times the normal annual pulpwood cut, and of hardwoods over 800 times the cut. In spite of this, we import more pulpwood, or its equivalent in wood pulp and paper, than we cut in our own forests. Obviously, only a small part of our 1,830 million cords of standing timber of the species now used in pulp and paper manufacture is available to the Nation's mills, or at least as available as some of the foreign supplies.

Sixty years ago the quantity of wood used as a raw material for paper in the United States was insignificant. Today about 85 percent of our paper has its origin in the forest. Wood, in short, is the basic raw material for paper pulp. Although pulp can be produced from any fibrous material, no source of cellulose has yet been discovered which, either in suitability for most types of paper pulp or in cost per unit weight, challenges the supremacy of wood.

Not all kinds of wood, however, are at present available for use in the manufacture of pulp. The spruces, firs, hemlocks, and pines, among softwoods; and cottonwoods and aspens, yellow poplar, birches, beech, maples, and gums, among hardwoods, are now used in sufficient quantities to warrant separate mention. The fact that different species require different processes for reduction to pulp tends to restrict their availability, particularly with respect to established mills.

STANDARD PULPWOODS AND PULPING PROCESSES

There are four standard processes of making paper pulp from wood—the mechanical, the sulphite, the sulphate, and the soda. Each is especially adapted to the manufacture of certain grades of paper or to the pulping of certain woods. The various grades of papers, in fact, usually contain varying proportions of two or more types of wood pulp. Considerable old paper also mingles with new pulp in various papers, and pulp derived from nonwoody plants mingles with wood pulp in fine papers.

Newsprint, cheap magazine, cheap catalog, and similar papers, are made mostly of mechanical pulp, that is of uncooked wood mechanically ground into a pulp. Only the relatively soft, light colored, nonresinous spruces, firs, and hemlocks are suitable for the manufacture of mechanical pulp or are used enough to be considered commercial sources for this process. The mechanical process is the cheapest of all, and the pulp yield is by far the greatest. The quality of the pulp, however, is so low that in the manufacture of even cheap papers considerable quantities of longer and stronger-fibered pulp are added. Of our total wood-pulp production, mechanical pulp comprises about a third.

The stronger and better-grade papers are made of pulps manufactured by one of the three standard chemical processes—sulphite, sulphate, or soda. In each of these processes a large portion of the wood is removed, leaving fibers consisting of almost pure cellulose. This is accomplished by cooking chips of the wood with a chemical under steam pressure.

Some classes of book, wrapping, bond, and tissue papers are made largely from sulphite pulp, and considerable sulphite is used in mechanical papers. The sulphite process is a little more expensive than the other chemical processes, and the pulp yield is only about half as large as in the mechanical process; but the pulp is very strong and can be readily bleached to a high degree of whiteness. The woods used in the sulphite process are the same as in the mechanical process; the light colored, nonresinous softwoods, such as spruce, fir, and hemlock. Sulphite pulp accounts for about a third of the wood pulp produced in this country.

Kraft or wrapping paper and high-test fiber board are made from sulphate pulp. The standard sulphate process is a little less expensive than the sulphite process; the yield of pulp is about the same. Any long-fibered wood can be used for sulphate pulp, even one which contain resins and other alkaline-soluble materials. Sulphate pulp constitutes about a fifth of our total wood-pulp production.

Book, lithograph, and envelope papers are very often made from a mixture of sulphite pulp and pulp made by the soda process. This mixture gives a sheet of paper which is highly esteemed by printers. The soda process can be applied to softwoods without difficulty, but it is used almost entirely for the reduction of such hardwoods as aspen, cottonwood, beech, birch, and gum. Soda pulp is sometimes used alone in the manufacture of some of the cheaper, bulkier book papers which have very low strength requirements. Of our total wood-pulp production, soda pulp constitutes only about a tenth.

With the above facts as to pulping processes and to woods suited to them as a background, the availability of present pulpwood supplies may be discussed region by region.

REGIONAL SUPPLIES

New England, Middle Atlantic, and Lake regions.—The spruce forests in New England and New York met the combined requirements for both mechanical and sulphite pulps better than those of any other section of the country, so that it has been here, and later in smaller degree under similar conditions in the spruce and hemlock forests of the Lake region, that the American industry has largely centered. This development also carried with it a considerable part of the sulphate-pulp industry, which could have located elsewhere and made use of other species. Even the soda-pulp industry, which began and is now well developed in Pennsylvania, manufactures a large part of its product from the aspen in the northern spruce forests.

The overcentralization of the industry intensifies the problem created by imports from other countries of pulpwood, pulp, and paper, and it is the chief factor in the situation which necessitates pulpwood imports. Fundamentally, we have imported pulpwood because the supplies of raw material tributary to the pulp mills of the New England, Middle Atlantic, and Lake regions have become increasingly scarce.

Pulp manufacture entered these restricted regions later than lumbering, and has reduced their diminished supplies of timber still further. Many pulp and paper mills have either no timber of their own or only very limited amounts, and few have permanent supplies. In the meanwhile, our paper requirements have grown faster than, under existing conditions, pulpwood could be obtained from our forests or wood pulp and paper could be produced in our mills. To keep up even in part with increasing demands, the industry was forced either to import both pulpwood and wood pulp, or to move to other regions of the United States.

Of late, a paper industry has sprung up in the lower Mississippi Valley, and the industry in the Pacific Coast region has expanded. In the main, however, the industry as a whole has chosen rather to import first pulpwood and then wood pulp and paper, on an ever-increasing scale (described in the later section headed "Timber Requirements") than to move. The principal factors influencing the choice were as follows:

Relatively large plant investments make it more difficult for pulp and paper mills to follow the retreating timber stands than is the case in lumber manufacture. Comparatively few woods, as previously indicated, have been used in paper making. Then, nearness to paper markets has been necessary to keep down transportation costs. These factors and the requirement, in the case of mechanical-pulp manufacture, of abundant and cheap power have tended to confine the production of paper to but few regions. Inertia alone has doubtless been a contributing factor in slowing up seemingly logical development. Perhaps one of the chief factors in the situation has been a lack of the technical knowledge needed to make the best use of the pulping resources of the country as a whole.

The great bulk of pulpwood imports into the New England, Middle Atlantic, and Lake regions consists of spruce and aspen. Fir pulpwood imports are comparatively small, and hemlock even smaller.

About 70 percent of the New England supply of spruce and fir is in Maine. (Table 5.) Perhaps as much as a sixth of the Maine timber is too scattered for profitable cutting, although in reasonably accessible territory. About a quarter is in a region now relatively inaccessible. Although some pulp manufacturers of New England are importing pulpwood from Canada in order to allow their American stumpage to build up by growth the majority are seemingly importing because the regional supply of pulpwood is not as available as foreign pulpwood, Even less of the New England wood is available if a long-term view is taken of the situation and if the present stands are regarded as absolutely essential forest capital on which interest must be earned in terms of growth. Competition with other uses, particularly lumber, must also be taken into account.

In the Lake States and in the Middle Atlantic region similar conditions of sparseness and inaccessibility of stand, and in the Lake States defectiveness of the fir, combine to make about the same proportion of the stand unavailable to the pulp and paper industry as in New England. Stands are being logged today for spruce pulpwood in New York which contain as little as two cords per acre.

In spite of having a domestic stand over 50 times as great as the annual consumption of domestic and imported wood combined, the Northeastern United States now imports nearly a third of its aspen pulpwood. This is due to poor distribution of present stands with respect to the soda-pulp industry. Pennsylvania produces almost no aspen of satisfactory pulpwood size, yet consumed 81,000 cords in 1929. Maine, although importing nearly a fifth of its aspen pulpwood, finds its own stands in remote locations unmarketable. Up to 1922, the quantity of aspen used for pulp in the Lake States was trifling, in spite of the known presence of enough standing timber to support a permanent industry using probably 200 thousand cords a year; by 1929 the use had jumped to nearly 60 thousand cords, under the stimulus of availability. The lumber industry offers little, if any, competition to the pulp and paper industry in the use of aspen.

In contrast to the scarcity of spruce and fir—a scarcity which is now being met by huge imports of pulpwood, wood pulp, and paper from foreign countries—is the abundance within the New England, Middle Atlantic, and Lake States of species such as beech, birch, maple, and various pines, which are already classed as pulp species, but which are relatively little used in these regions. Full use of these species now available seems the most promising solution of the immediate problem of availability in the older pulp- and paper-producing regions. Research, both at the Forest Products Laboratory of the United States Forest Service and in commercial plants, has amply demonstrated the possibility of adapting pulping processes to their extensive use. Some of these possibilties have been discussed in Department of Agriculture Bulletin No. 1241, "How the United States Can Meet Its Present and Future Pulpwood Requirements."

Pacific Coast region.—The opportunity in the Pacific Coast region for still larger sulphite- and mechanical-pulp industries is based on supplies of virgin spruce, fir, and hemlock many times larger than those in any other forest region of the United States (table 5). Even larger stands of pine afford a similar opportunity to increase the production of sulphate pulp and the grades of paper, such as wrapping and boards, manufactured therefrom. This region also contains an abundance of available water power. Of the total potential horsepower estimated for the United States, about two fifths is in this region.

The fact that the pulp and paper industry in the Pacific Coast region must, to some extent at least, compete for raw material with a very large and well-developed lumber industry is not necessarily a disadvantage. There is no reason other than a lack of pulpwood markets why there should not be operations designed primarily to secure pulpwood, or why operations in stands containing a large percentage of pulp species should not be designed to secure lumber from the material most suitable for that purpose and pulpwood from the remainder of the stands.

There are great possibilities in this region for the integration of the lumber and pulp and paper industries; in fact, in Washington, which ranks first in lumber production and fourth in pulp production, an approach to integration has already been made. Such integration would make feasible not only a more profitable utilization of saw-log material but also a large use of both logging and sawmill waste. Of the 956 thousand cords of pulpwood consumed in Washington in 1929, 387 thousand cords consisted of slabs or other sawmill waste. Logging operations in western Washington alone annually produce 500,000 cords of small and low-grade Douglas fir, western hemlock, Sitka spruce, and "true" fir logs which are difficult to dispose of profitably and which could doubtless be used more advantageously for pulp than lumber. It would be possible to draw from the areas logged over annually in western Washington an additional 500,000 cords, by taking out material but little smaller or but little more defective than that which is logged primarily for lumber. It is therefore possible to obtain 1 million cords of pulpwood annually in western Washington from operations designed primarily for lumber, without taking into account the possibility of utilizing the 3 million cords of material of cordwood size or larger left annually in the woods after logging in the form of small or broken timber.

South region.—The spruce-fir-hemlock timber of the South has less significance than similar amounts of the same species in either the New England, Middle Atlantic, or Lake regions (table 5). These stands, which occupy a relatively limited area on the higher slopes of the southern Appalachian Mountains, are estimated at less than 5 million cords, and the prospect that they will reproduce after commercial logging as now conducted is far less certain than in the more northerly regions.

As earlier described, the various stands of soda-pulp species—cottonwood, yellow poplar, birch, beech, maple, and gum—have for the most part been more or less heavily and repeatedly cut over in the past. Although cutting exceeds growth, there are undoubtedly many areas from which a large volume of pulpwood could be taken as thinnings and improvement cuttings; in fact, its removal might be made to constitute one step toward better forest management. With proper methods of forest management in the cutting, and thereafter, it should easily be possible for the South to take care of our present national requirement for soda-pulp timber and to enlarge production to absorb our increasing needs for years to come. Relatively small areas could, if worked for pulpwood alone, be made to produce the entire volume required.

For sulphate pulp, as shown by table 5, the Southern States from Virginia to Texas have a large supply of suitable timber and the additional advantage of easy access to the principal markets of the country. The South, moreover, is capable of reproducing stands of southern yellow pines suitable for pulping purposes in approximately 25 years, a rate impossible elsewhere in the country except in the Pacific Coast region.

The rapid growth of a pulp and paper industry in the South during the past decade has undoubtedly been due in a large measure to an abundant supply of southern yellow pines. (Table 5.) The principal product at present is sulphate or kraft pulp. It has been found that a kraft pulp can be made from southern yellow pine that is quite as strong and as satisfactory in texture as is obtained from other species and other localities. With the exception of a mill or two producing bleached book papers from the pines, the insulation and pressed-wood-board developments utilizing bagasse and pine sawmill waste, respectively, and several recently built "semichemical" pulping plants, all of the establishments in the South make this brown kraft pulp. The utilization of kraft for cement bags and similar containers has given this industry considerable impetus. The South now can be said to dominate the kraft pulp field.

The trend in the South at the beginning of the depression was toward a considerable enlargement of the kraft pulping industry. The cheap pulpwood, together with proper attention to the technical improvements necessary to produce pulps equal or superior to imported products, may well win the kraft market for southern producers. When it is considered that the United States imported 450 thousand tons of sulphate pulp in 1929, the possibilities for great development in the South without cutting in on present domestic production elsewhere can be realized.

The raw material for an indefinite expansion of the kraft industry in the South is even more readily available than that for expansion of the soda-pulp industry. There are over 100 million acres of southern pine lands, and even a tithe of their possible annual production of wood can supply not only the present American but the world demand for kraft papers. Moreover, should recent technical developments by the Forest Products Laboratory of the Forest Service be taken advantage of commercially, permitting the branching out of the industry or the development of lines other than brown pulps, the necessary timber is still abundantly available in this region.

It has been more than 10 years since the Forest Products Laboratory announced a method for the production of bleached book and magazine papers from southern yellow pines and gums. Ordinary kraft pulp is very difficult to bleach and the usual bleached product is of low strength. The new method involves the use of the sulphate or kraft process with certain modifications, but the chief point of difference is the use of a two-stage system of bleaching. The findings of this research are practiced by not more than one or two southern mills, and consequently only a small amount of book paper is at present made in the South. Elsewhere, however, progress in the two-stage bleaching practice has gone on apace. Savings made possible by this practice have resulted in the installation of two-stage systems in many pulp mills operating on spruce and hemlock. Thus, the practicability of the idea is established. Its intensive application to southern woods should make them available to the book-paper industry.

Another investigation had the objective of combining strength, heretofore lacking in bleached southern yellow pine papers, with lightness of color. Such a pulp is especially desirable since to a certain extent it would be a substitute for the sulphite pulp used in newsprint, wrapping papers, and bond. It was found that by modifying the sulphate process a better yield of southern yellow pine pulp could be obtained, also a pulp that could be bleached without serious loss of strength. The method has thus far been used only with loblolly and longleaf pine, but appears to be generally applicable to the other pines.

Concurrently with the study of the pines, the Forest Service has conducted experiments with the gums and other southern hardwoods. They have revealed that the sulphite process works satisfactorily with the gums, particularly black and tupelo gums, yielding a fairly strong pulp that bleaches easily to a blue-white color. It appears that a book paper can be made by a combination of bleached pine sulphate pulp and of bleached gum sulphite pulp. Most book papers contain bleached spruce sulphite along with soda pulp, which is usually made from aspen. The long-fibered pine sulphate would take the place of the spruce sulphite; and the gum sulphite, which would replace the soda pulp, would impart the blue-white color so greatly desired.

Another new development particularly suited to the reduction of the southern hardwoods, which was also worked out at the Forest Products Laboratory, is the so-called "semichemical process." It is employed by at least five plants in pulping extracted chestnut chips, a byproduct of tanning extract plants. Prior to 1925, these chips were used only as fuel, but with the advent of the new process they were successfully converted into corrugated paper stock. At another mill semichemical gum pulp is converted into machine-glazed wrapping papers of a light color. By a little more careful selection of the wood this mill could undoubtedly produce from gum a semichemical paper suitable for cheap print or tablet use. The semichemical process not only gives high yields of pulp, but also a pulp capable of considerable development as to strength. There is a possibility that semichemical pulp can to an extent take the place of the more expensive kraft paper, now used in the manufacture of pulpboard. It appears particularly promising for use in a mixture with kraft for container lining. In view of the already extensive development of the semichemical process in the South and its unquestioned possibilities, the very large quantity of gums and other hardwoods in the South should be considered available to the pulp and paper industry there.

North and south Rocky Mountain regions.—These two western regions afford an opportunity for enlarged sulphite and mechanical pulp operations, but to a much smaller degree than the Pacific Coast region or Alaska. They afford a similar opportunity for sulphate pulp, but here also in much smaller degree than in the Pacific Coast region or the South. The opportunity in both cases is based, as in Alaska and the Pacific Coast region, on remaining supplies of virgin timber. (Table 5.) At present, the industry is less developed in the Rocky Mountain States than in any other forested region of the United States.

Alaska.—Our pulpwood resources are not confined to the 48 States. Southeastern Alaska, in fact, is one of the two outstanding regions with large virgin stands of softwoods adapted for sulphite and mechanical pulps. As compared with western Oregon and Washington, southeastern Alaska has the advantage of practically pure stands of spruce and hemlock, lower stumpage prices, and cheaper power.

It has the disadvantage of being considerably farther from the large paper markets, and of pioneer conditions which would tend to hamper the development of an industry. In southeastern Alaska, cutting operations for lumber and other purposes are very small, so that in this respect there would be a greater opportunity for the development of a dominant pulp and paper industry than in any of the Western States.

Southeastern Alaska is within the range of the extensive Pacific Coast forest, which occurs in western Oregon, Washington, and British Columbia and along the southern coast of Alaska as far north and west as the Aleutian Peninsula and Afognak Island. It is essentially a timber-producing region. Aided by mild temperature and abundant rainfall, the region supports extensive stands of rapidly growing trees; because of rough topography and thin soil, perhaps less than 1 percent of the area is suitable for farming. In view of the high latitude, an outstanding climatic feature is the mild winter temperatures. There are no climatic factors which prevent or seriously hinder the operation of wood-working establishments throughout the year.

Nearly all the land in southeastern Alaska is owned by the Federal Government, and nearly 17 million acres, or 73 percent, has been included in the national forest system to be administered primarily for continuous production of timber crops and a sustained yearly output of raw material for local wood-using industries. Of the 17 million acres only 3 million acres bears commercial timber.

There is little timber in private ownership in southeastern Alaska. All but about 1½ billion board feet is in the Tongass National Forest. The volume of commercial timber in the Tongass National Forest is estimated as follows:

	Board feet
Western hemlock	58, 000, 000, 000
Sitka spruce	15, 800, 000, 000
Western red cedar	2, 350, 000, 000
Alaska cedar	2, 350, 000, 000
Total	78, 500, 000, 000

The western hemlock and Sitka spruce stands are characteristically even aged. Many age classes are represented in the forest as a whole, but the older classes are greatly in the majority, with perhaps three fourths of the commercial timber of the region mature or overmature.

Although this 78.5 billion board feet of commercial timber averages about 26 thousand board feet per acre, individual logging units vary widely from this average. A volume of 30 to 40 thousand board feet per acre is common on many extensive areas, and 50 thousand feet or more per acre is not unusual on small units. The majority of the merchantable trees are from 24 to 48 inches in diameter and from 90 to 140 feet high.

The commercial forests extend from tidewater to an elevation of about 1,500 feet. Because of prevailing steep slopes, they form relatively narrow bands along the shore lines of the mainland and islands, rarely extending inland more than 5 miles, except along the valleys of the few large streams. A large percentage of the timber can be logged directly to tidewater by the use of 2 or 3 logging engines working tandem. Floating logging camps, easily towed from one cutting area to another, are in general use. Similarly, donkey engines and all logging equipment are moved on scows and floats.

The extensive forest resources of southeastern Alaska are likely to be exploited chiefly for the manufacture of newsprint paper, because of the favorable conditions there for large-scale operations that now characterize that industry. Conditions are not so good, however, for other branches of the paper industry, or for the extensive manufacture of lumber.

It is estimated that the forests of southeastern Alaska, under a proper system of management, can produce in the neighborhood of 1½ million cords of pulpwood annually in perpetuity. Converted into newsprint this represents a production of 1 million tons, or more than one fourth of the present yearly consumption of newsprint in the United States.

NAVAL-STORES TIMBER

Under the general term "Naval Stores" are included turpentine and rosin. In the United States these two commodities are all derived from longleaf and slash pine timber in the group of States from North Carolina to Texas. About 87 percent of the product is manufactured from the gum gathered from the living pine tree and is known as gum turpentine and rosin. The remaining 13 percent is distilled from the pitchy stumps and down wood left after logging, and is known as wood turpentine and rosin. In considering the availability of naval-stores resources these two sources of naval stores must be kept in mind.

The longleaf-slash pine forests of the South are now almost entirely second growth; of the total area of this type of forest only about 5 percent is old-growth timber. The naval-stores belt embraces the entire type, which extends in a broad band from central North Carolina southwestward, parallel to the coast, through North and South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and eastern Texas. (Fig. 2 of section, "Forest Land the Basic Resource.") Of the total area of nearly 52 million acres, it is estimated that 27 percent is either denuded or unsatisfactorily restocked; 5.6 percent is old-growth saw timber; and the remainder, or 67.4 percent, is in second-growth longleaf and slash pine stands of varying ages, sizes, and degrees of stocking. The 35 million acres or so which the existing young stands cover is mainly in Georgia and Florida.

The area of greatest production is even smaller. Over 80 percent of American gum naval stores is now produced from a forest area of approximately 13 million acres in southeast Georgia and north Florida, where the timber is almost entirely second growth. The chief reason for this concentration of the industry on only about a quarter of the total area in the naval-stores belt is that in this region the young growth has more uniformly restocked the cut-over land and has had more time to grow to workable size than elsewhere. The devastated areas and the areas that are not restocking satisfactorily are found to a greater extent in the more recently cut-over lands in Mississippi, Louisiana, and Texas.

Almost no naval-stores timber is inaccessible to operation. Although there is, of course, a lower limit to the number of trees per acre which it is profitable to turpentine, yet, if site quality and other conditions are such that any second growth at all comes up, the result is generally the establishment of a stand dense enough to work at a profit. A far more important limiting factor is the average size of the timber.

The available old-growth stands and the larger trees in the oldest second-growth stands have been or are now being worked for turpentine. As to future crops of naval-stores timber, almost all that is known of the approximately 35 million acres of second growth is that it includes stands generally varying in age from 1 to 30 years, and in degree of stocking from 1/10 up. Little data are available, as to the exact proportion of the various size classes of young growth, upon which to base any reliable prediction of the supply of timber for future operations. In many sections of the naval-stores belt there seems to be a shortage in the 4-inch to 6-inch diameter classes, upon which the gum industry must depend largely for its new cupping material in the near future. It is generally believed that there may be a lack of timber of turpentine size for a short while ahead, probably the next decade. However, there is now growing in the naval-stores belt a sufficiently large number of young trees in the 2-inch to 4-inch diameter classes to maintain, when it has grown to workable size, an industry of the present size.

Thus, so far as permanence of timber supply is concerned, the future of the gum naval stores industry seems assured, provided that a sane policy of forest protection and management is followed. There is sufficient land and there will be ample regrowth of the timber if nature is not handicapped by wholesale uncontrolled burning in regeneration areas. Moreover, under improved methods of operation and timber management already known to the industry, the timber when grown to workable size can be made to produce more gum at smaller cost and with less loss of the residual lumber value than under current methods.

The possible shortage of timber suitable for cupping in the near future is not a serious check to the industry as a whole, nor is it likely to result in any material shortage of naval stores products, even temporarily. In the first place, a large surplus or accumulation of stocks is already on hand and must be absorbed during the next few years; in the second, the wood naval-stores industry may be capable of increasing its output sufficiently to bridge whatever shortage may develop in gum naval-stores production. The amount of pine stumps and retort wood from which wood naval stores are derived appears to be ample to meet the demands of this branch of the industry for years to come.

Character of ownership has had a very profound effect upon the conduct of the industry. One of the great difficulties under which the industry labors, in common with other natural-resource industries, has been overproduction. The capital required to establish a turpentine still is relatively small, and even a slight rise in the price of naval stores has encouraged new stills to start operation. Studies by the Southern Forest Experiment Station and other branches of the Forest Service have thoroughly established the fact that the smaller trees in a stand are turpentined at a loss. But it is almost impossible to persuade a large number of small landowners that they will profit by leaving their small timber unturpentined. If the timber were more strongly held, the small trees would be kept off the market, and the entire industry would profit in the long run. The factors who finance most of the naval-stores operations have the best opportunity to encourage good practice and put the industry on a better basis. They are usually to be found on the side of progressive ideas in turpentine practice and in favor of timber conservation.

The American production of naval stores is about twice the domestic consumption. Moreover, 80 percent of it is being obtained from only about one quarter of the total forest area adapted to naval-stores production. It seems therefore that, so far as the American consumer of turpentine and rosin and other derived products of the naval-stores industry is concerned, the prospective timber supplies are more than adequate to meet our requirements. It would be a great mistake, however, to view the naval-stores situation purely from the point of view of our national requirements and to ignore the consequences of a possible shrinkage of the industry to a point where it would be capable of satisfying only American needs. A permanent naval-stores industry of present or greater size would give steady employment to a very large local population in the pine woods of the South. It would be the means of keeping in highly productive use great areas of land not adapted to agriculture, and would therefore contribute materially to a well-rounded program of land use. From every point of view the naval-stores industry, as an industry, independent of this country's direct need of the product obtained, is a distinct asset to the United States.

The present magnitude of our naval-stores industries and the possibilities of an even larger industry in the future make wise management of this resource a matter of public welfare. To plan for such management, however, adequate information must be available. At present, comprehensive data on the extent, character, and availability of naval-stores timber in the South are quite lacking. In fact, the outstanding need in the naval stores belt for both the gum and the wood naval-stores industries, as well as timberland owners generally, financiers, lawmakers, and State and county administrators, is an immediate inventory of forest resources and a survey of the industrial situation from all angles.

The permanence and future welfare of the naval-stores industries themselves depend in no small measure on an accurate knowledge of fundamental conditions. The industry has benefited enormously by the campaign against uncontrolled forest fires which was begun comparatively recently in the Southern States. But it must have far better information than it has now on a number of other vitally important matters before it can put its house fairly in order.

As a producer of wealth and as a field for labor, the naval-stores industry is an important factor in the economic life of the South. Many economists consider it the economic key to the successful reforestation of much of the forest land in the South. That it must be given great weight in any balanced land-use program in the States embraced in the naval-stores belt is not questioned.

FOREST DRAIN

In any analysis of our forest resources, a fundamental consideration is that of current forest drain, or the volume of material removed from the forests annually by cutting and by fire, insects, disease, and other destructive agencies. Of equal importance are estimates of annual growth, and of the relation between drain and growth, treatment of which will follow. The present discussion will be confined to the important aspects of the situation as to forest drain.

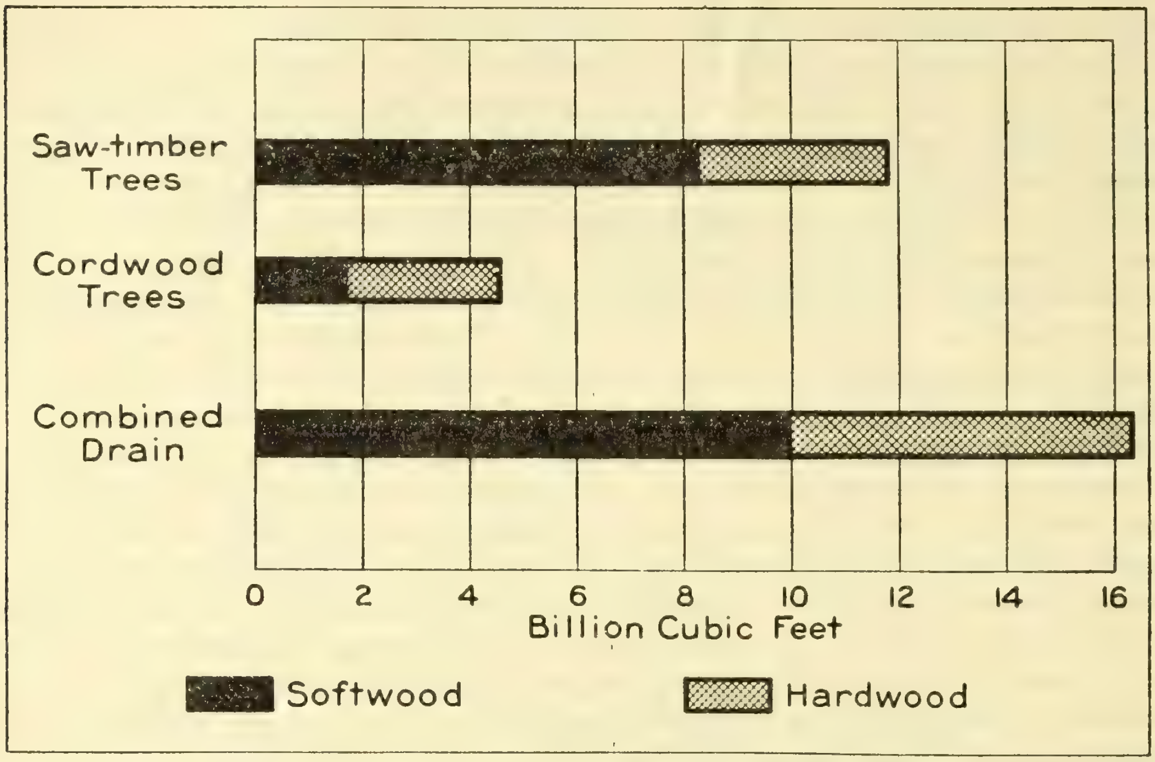

FIGURE 10.—Drain (cut and losses) on the commercial forests of the United States by character of growth and class of wood.

The estimate of present annual drain on the commercial standing timber in the United States is more than 16 billion cubic feet (table 10 and figs. 10 and 11). In this total, the figures for timber cut are based upon the average quantity of commodities produced from domestic

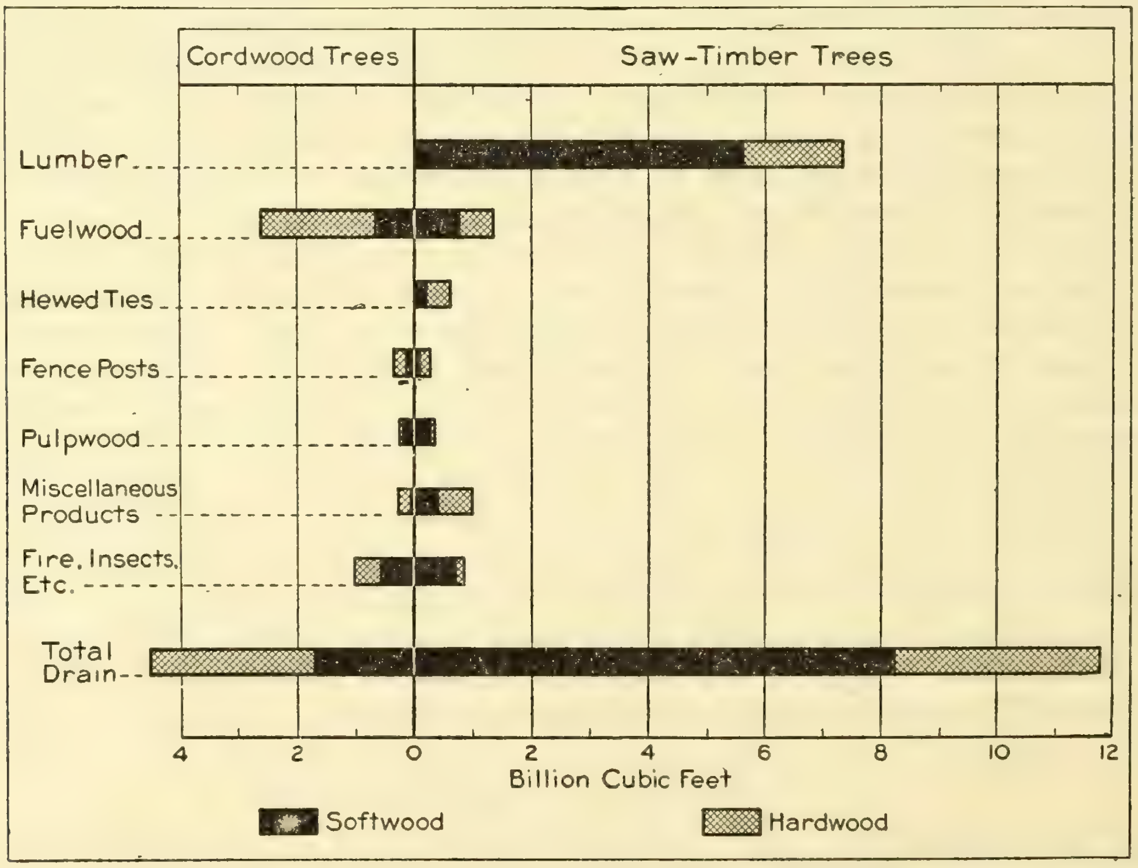

FIGURE 11.—Drain on the commercial forests of the United States through use or loss from destructive agencies, shown by character of growth and class of wood.

timber during the years 1925 to 1929, inclusive. This period was chosen as covering the years for which more and better statistics were available than for any other recent period. It avoids not only the subnormal swing of the economic depression, but also the earlier trends that are out of line with present-day production. The drain averages thus obtained represent merely the conditions for these years and are not necessarily to be considered as an index of future wood requirements.

Timber destroyed includes only large-scale timber losses, not salvaged, over and above the normal losses through the death and decay of individual trees, for which allowance is made in estimating growth. Losses other than those from fire and naval-stores operations are averaged for the period 1920 to 1929, instead of 1925–29, the longer period permitting the inclusion of a greater number of less frequent, cataclysmic disturbances and thus insuring a better average figure.

TABLE 10.—*Total timber cut or destroyed each year in the commercial forests of the United States, by agencies* [1]

Agency	All timber			Saw-timber trees		
	Total	Softwood	Hardwood	Total	Softwood	Hardwood
	M cu. ft.	*M cu. ft.*	*M cu. ft.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*
Timber cut [2]	14, 495, 308	8, 683, 886	5, 811, 422	54, 641, 444	40, 228, 682	14, 412, 762
Fire losses [3]	870, 690	601, 490	269, 200	1, 390, 233	1, 250, 948	139, 285
Other losses [4]	985, 209	697, 111	288, 098	3, 402, 162	3, 075, 284	326, 878
All agencies	16, 351, 207	9, 982, 487	6, 368, 720	59, 433, 839	44, 554, 914	14, 878, 925

Agency	Cordwood trees		
	Total	Softwood	Hardwood
	Cords	*Cords*	*Cords*
Timber cut [2]	35, 486, 179	11, 141, 362	24, 344, 817
Fire losses [3]	6, 903, 718	4, 231, 994	2, 671, 724
Other losses [4]	4, 081, 362	1, 742, 426	2, 338, 936
All agencies	46, 471, 259	17, 115, 782	29, 355, 477

[1] For definiation, explanations, and general make-up of this table see footnotes in subsequent timber-loss tables and also refer to text.

[2] Timber cut annually, 1925 to 1929, inclusive.

[3] Timber killed annually by fire and not utilized, 1925 to 1929, inclusive.

[4] Timber killed annually by insects, disease, drought, wind, naval-stores operations, etc., and not utilized, 1920 to 1929, inclusive.

The total drain figure of 16 billion cubic feet (table 10) is in contrast with that of 26 billion cubic feet estimated by the Forest Service in 1920 in the report on Senate Resolution 311, on the basis of the 1910–19 period. The differences between the two estimates are due in part to the decrease in the use of wood for fuel from 110 million cords in the 1920 estimate to 61 million in the present estimate. Elimination of bark (as in the case of the timber stand and growth estimates) and the use of improved conversion factors also had the effect of reducing the present estimate. The present figure for saw-timber drain (59 billion board feet) is actually larger than the 1920 estimate (56 billion feet), because of the different and improved methods employed in making the estimate.

As indicated in table 10 and figure 12, cutting accounts for 89 percent of the total, fire for 5 percent, and disease, insects, etc., for 6 percent. Seventy percent of the total drain is represented by the 59 billion board feet (11½ billion cubic feet) that comes out of saw-timber trees (table 11 and figure 11), of which 55 billion board feet is taken by the annual timber cut.

The total drain on saw timber is about five times, and on total timber volume nearly twice, the estimated current annual growth. It may be correctly inferred from this that the forest resources of this country are being seriously depleted. The national situation, however, is a complex of regional situations which vary widely as to the relation between drain and growth. An adequate understanding of the matter can be had only by a more detailed consideration of this complex, such as is given in other pages of this section.

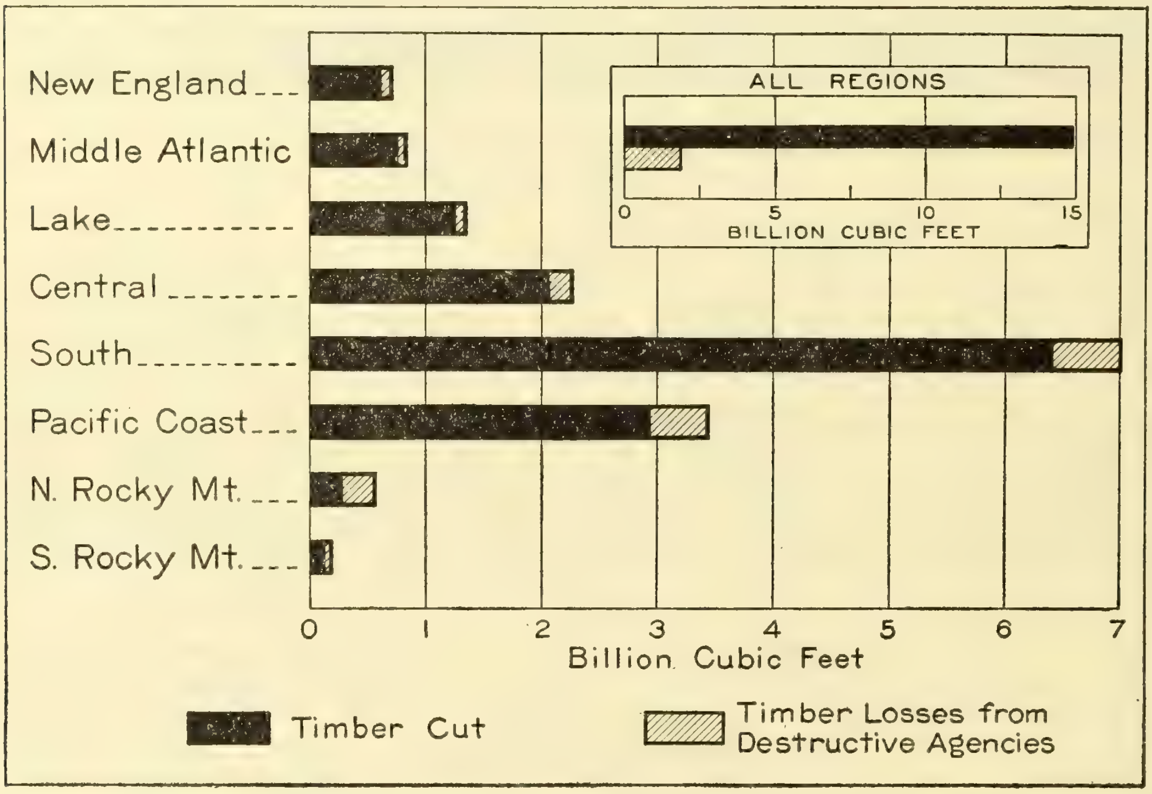

FIGURE 12.—Total drain on the commercial forests of the United States by regions.

TABLE 11.—*Total timber cut or destroyed each year in the commercial forests of the United States, by regions* [1]

Region	All timber				Saw-timber trees	
	Total		Softwood	Hardwood	Total	
Eastern regions:	*M cu. ft.*	*Percent*	*M cu. ft.*	*M cu. ft.*	*M ft. b. m.*	*Percent*
New England	706, 010	4	362, 657	343, 353	1, 904, 797	3
Middle Atlantic	835, 077	5	145, 081	689, 996	1, 082, 885	2
Lake	1, 343, 360	8	492, 780	850, 580	2, 747, 810	5
Central	2, 263, 087	14	250, 310	2, 012, 777	5, 525, 089	9
South	7, 011, 589	43	4, 557, 136	2, 454, 453	26, 339, 261	44
Total	12, 159, 123	74	5, 807, 964	6, 351, 159	37, 599, 842	63
Western regions:						
Pacific Coast	3, 444, 011	21	3, 427, 113	16, 898	18, 799, 052	32
North Rocky Mountain	566, 328	4	566, 247	81	2, 377, 634	4
South Rocky Mountain	181, 745	1	181, 163	582	657, 311	1
Total	4, 192, 084	26	4, 174, 523	17, 561	21, 833, 997	37
All regions	16, 351, 207	100	9, 982, 487	6, 368, 720	59, 433, 839	100

[1] Combined average annual drain; cutting, 1925 to 1929, inclusive; fire losses, 1925 to 1929, inclusive; insects, disease, drought, wind, naval stores operations, etc., 1920 to 1929, inclusive. For definitions, explanations, and general make-up of this table see footnotes in subsequent timber-loss tables and also refer to text.

TABLE 11.—*Total timber cut or distroyed each year in the commercial forests of the United States, by regions*—Continued

Region	Saw-timber trees		Cordwood trees			
	Softwood	Hardwood	Total		Softwood	Hardwood
Eastern regions:	*M ft. b.m.*	*M ft. b.m.*	*Cords*	*Percent*	*Cords*	*Cords*
New England	1, 514, 441	390, 356	3, 120, 456	7	455, 587	2, 664, 869
Middle Atlantic	350, 620	732, 265	6, 089, 097	13	720, 661	5, 368, 436
Lake	1, 328, 977	1, 418, 833	7, 110, 679	15	1, 909, 843	5, 200, 836
Central	982, 937	4, 542, 152	10, 638, 875	23	579, 691	10, 059, 184
South	18, 595, 540	7, 743, 721	16, 100, 004	35	10, 106, 455	5, 993, 549
Total	22, 772, 515	14, 827, 327	43, 059, 111	93	13, 772, 237	29, 286, 874
Western regions:						
Pacific Coast	18, 749, 881	49, 171	1, 581, 705	3	1, 514, 339	67, 366
North Rocky Mountain	2, 377, 264	370	1, 406, 136	3	1, 406, 136	----------
South Rocky Mountain	655, 254	2, 057	424, 307	1	423, 070	1, 237
Total	21, 782, 399	51, 598	3, 412, 148	7	3, 343, 545	68, 603
All regions	44, 554, 914	14, 878, 925	46, 471, 259	100	17, 115, 782	29, 355, 477

The ratio of drain to stand in hardwood saw timber is nearly three times that for softwood saw timber. Similarly, in total volumes, the hardwood ratio is about two times. This is consistent with the generally known fact that depletion is proceeding more rapidly in the hardwoods than in the softwoods, and that the problem of adequate hardwood supplies is more acute.

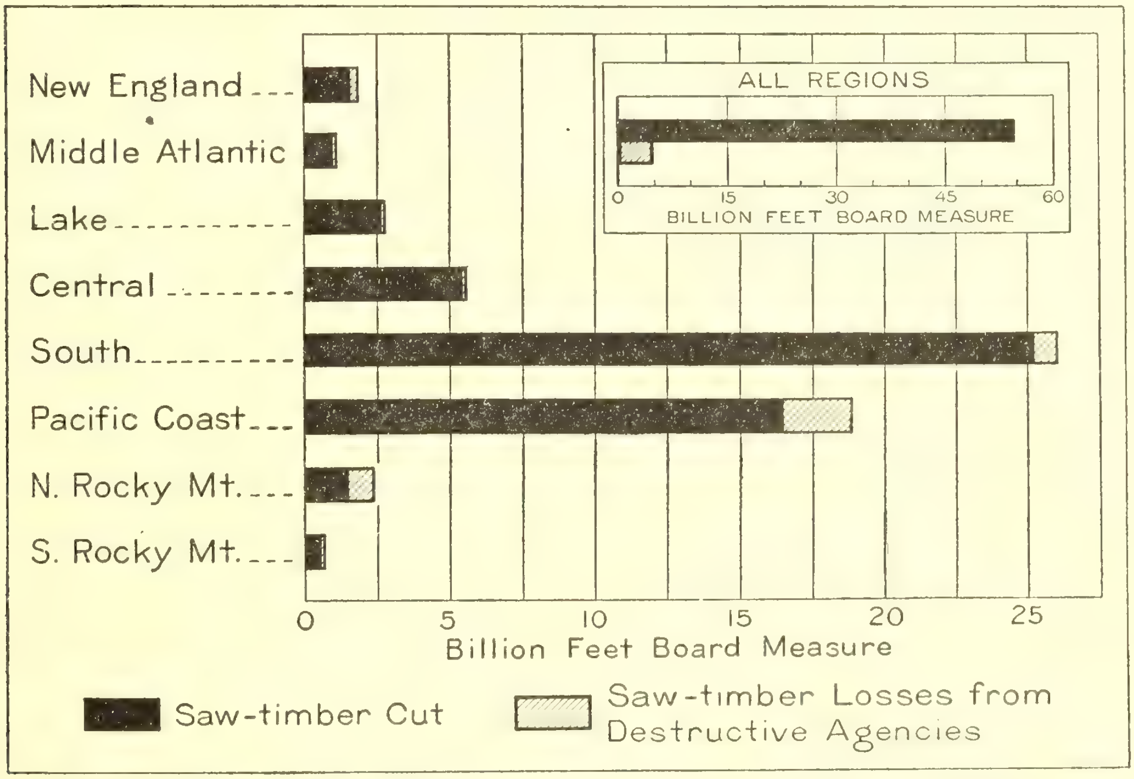

FIGURE 13.—Total saw-timber drain on the forests of the United States by regions.

In annual drain (in cubic feet) for all classes of timber (table 11 and fig. 12) the forests of the East account for three times as much as those of the West; more than half of the volume of the eastern cut is from hardwoods, while that from western hardwoods is insignificant. The large excess of the South over the Pacific coast consists principally of hardwood saw timber and cordwood trees. Total southern drain is about three times that of the Central States but here the excess is very largely in the softwood saw-timber trees. The saw-timber drain in the South (in board feet) is also much higher than that in the Pacific-coast region (fig. 13), but the difference is not so great as in the comparison of drain for all classes of timber, because of the fact that saw timber comprises a larger proportion of the total drain in the Pacific-coast region. These facts further emphasize the important place which the South holds in the forest affairs of the country, but they also show that, in the relation of forest depletion to softwood timber stands, the Pacific Coast is in a far more favorable position.

TIMBER CUT

The United States is by far the largest consumer of wood in the world. Although imports of forest products into the United States are larger, as a whole, than exports, both are comparatively small, so that United States consumption (with the rather notable exception of pulpwood) is closely reflected by the timber cut of the United States.

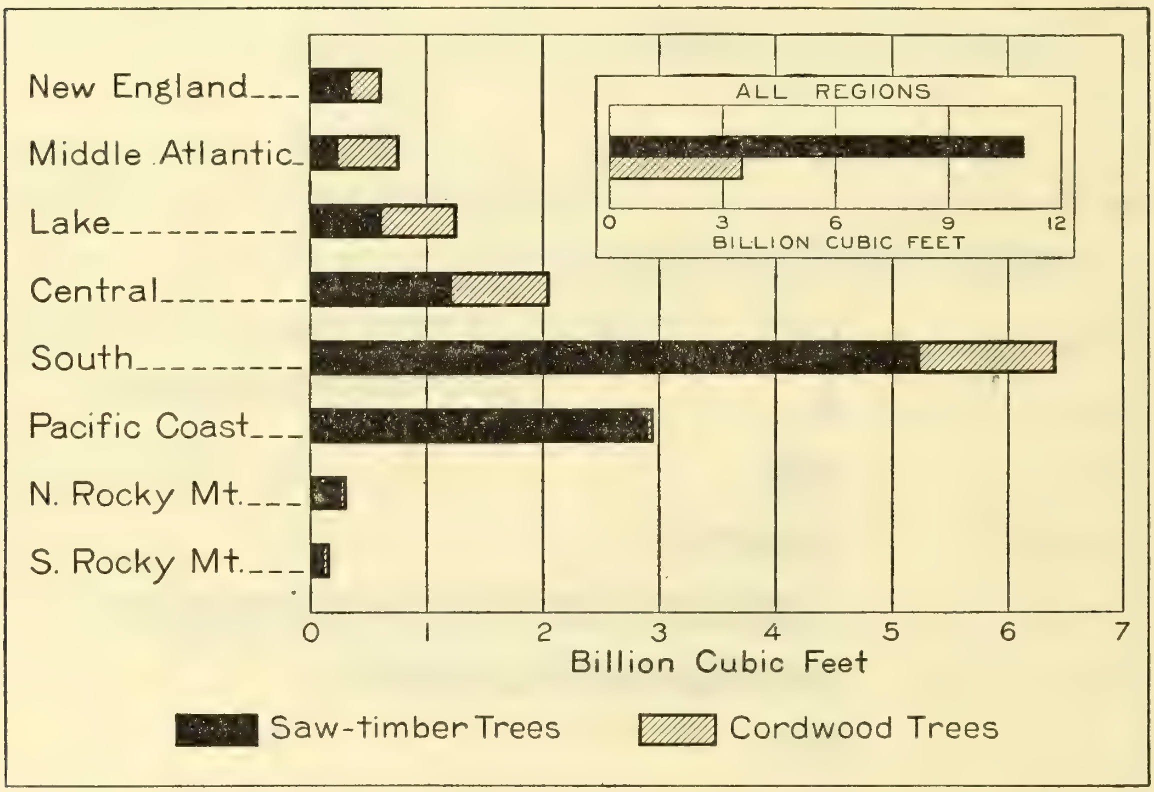

FIGURE 14.—Total timber cut on the forests of the United States by tree size and region.

The annual cut from saw-timber trees and from smaller trees in the United States amounts to about one half and one sixth, respectively, of the world's consumption. The combined United States cut of 14½ billion cubic feet (table 12) is about one third of the world consumption. Three fourths of the world's saw-timber consumption and half of the total wood consumption is softwood. In the United States 74 percent of the saw timber and 60 percent of the combined timber cut is softwood. The per capita cut of the United States is estimated to be 118 cubic feet, of which 89 cubic feet (445 board feet), or 75 percent, is from trees of saw-timber size.

Table 13 shows the proportion of timber drain represented by the most important commodities produced from saw timber and cordwood trees separately and combined (figs. 14 and 15).

Table 12.—*Timber cut each year in the commercial forests of the United States, by regions* [1]

Region	All timber				Saw-timber trees	
	Total		Softwood	Hardwood	Total	
	M cu. ft.	*Percent*	*M cu. ft.*	*M cu. ft.*	*M ft. b.m.*	*Percent*
Eastern regions:						
New England	619, 147	4	293, 503	325, 644	1, 647, 827	3
Middle Atlantic	771, 592	6	131, 618	639, 974	1, 061, 559	2
Lake	1, 266, 825	9	469, 049	797, 776	2, 708, 807	5
Central	2, 066, 846	14	239, 387	1, 827, 459	5, 453, 791	10
South	6, 417, 934	44	4, 214, 926	2, 203, 008	25, 232, 821	46
Total	11, 142, 344	77	5, 348, 483	5, 793, 861	36, 104, 805	66
Western regions:						
Pacific Coast	2, 937, 390	20	2, 920, 492	16, 898	16, 486, 839	30
North Rocky Mountain	287, 190	2	287, 109	81	1, 510, 140	3
South Rocky Mountain	128, 384	1	127, 802	582	539, 660	1
Total	3, 352, 964	23	3, 335, 403	17, 561	18, 536, 639	34
All regions	14, 495, 308	100	8, 683, 886	5, 811, 422	54, 641, 444	100

Region	Saw-timber trees		Cordwood trees			
	Softwood	Hardwood	Total		Softwood	Hardwood
	M ft. b.m.	*M ft. b.m.*	*Cords*	*Percent*	*Cords*	*Cords*
Eastern regions:						
New England	1, 284, 467	363, 360	2, 722, 673	8	191, 934	2, 530, 739
Middle Atlantic	348, 798	712, 761	5, 436, 526	15	576, 039	4, 860, 487
Lake	1, 321, 233	1, 387, 574	6, 273, 311	18	1, 676, 205	4, 597, 106
Central	980, 500	4, 473, 291	8, 628, 934	24	465, 105	8, 163, 829
South	17, 808, 643	7, 424, 178	11, 827, 417	33	7, 703, 364	4, 124, 053
Total	21, 743, 641	14, 361, 164	34, 888, 861	98	10, 612, 647	24, 276, 214
Western regions:						
Pacific Coast	16, 437, 668	49, 171	307, 172	1	239, 806	67, 366
North Rocky Mountain	1, 509, 770	370	133, 983	(2)	133, 983	----------
South Rocky Mountain	537, 603	2, 057	156, 163	1	154, 926	1, 237
Total	18, 485, 041	51, 598	597, 318	2	528, 715	68, 603
All regions	40, 228, 682	14, 412, 762	35, 486, 179	100	11, 141, 362	24, 344, 817

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[1] Average for years 1925 to 1929, inclusive. Basic data from reports of the Census of Manufactures, the Forest Service, and information supplied by State and commercial organizations. For definitions, explanations and general make-up of this table, see footnotes in subsequent timber-loss tables and also refer to text.

[2] Less than one half of 1 per cent.

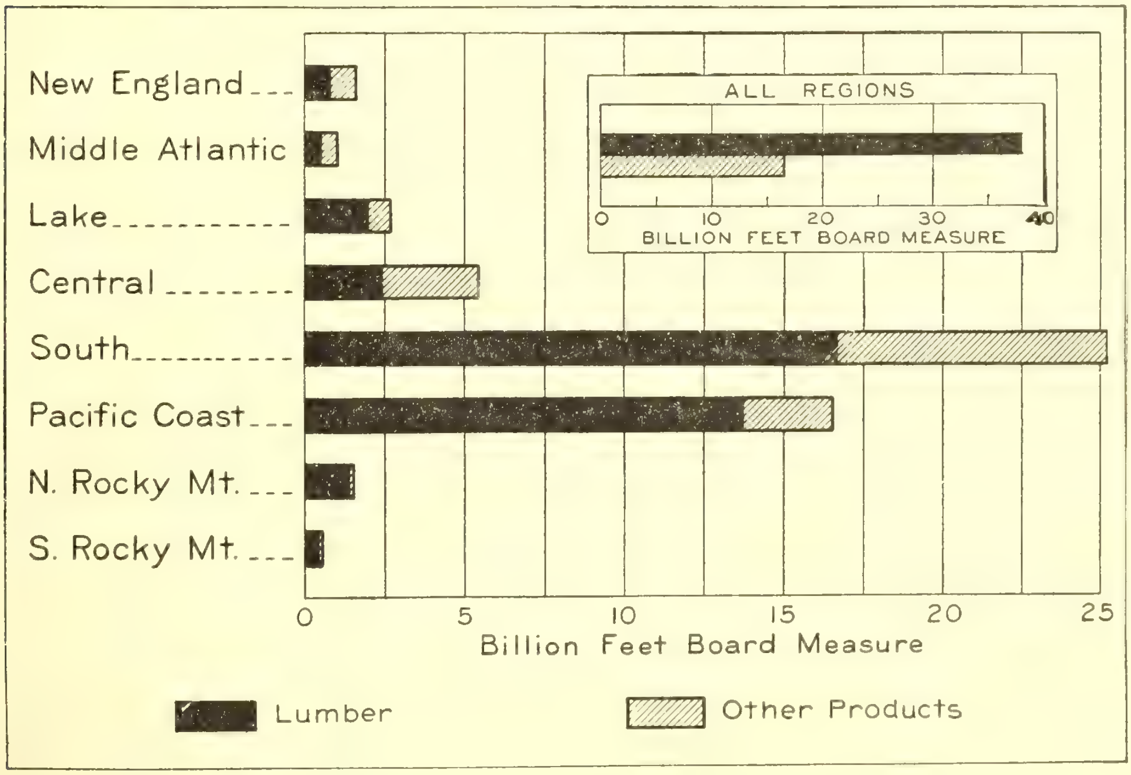

Figure 15.—Total saw-timber cut on the forests of the United States by use and region.

LUMBER

Lumber stands out as by far the most important single commodity into which the timber cut of this country enters. It accounts annually for 70 percent (38 billion board feet) of the saw-timber cut, and for about 50 percent (7 billion cubic feet) of the total cut. About four fifths of this huge lumber production is softwood (table 13).

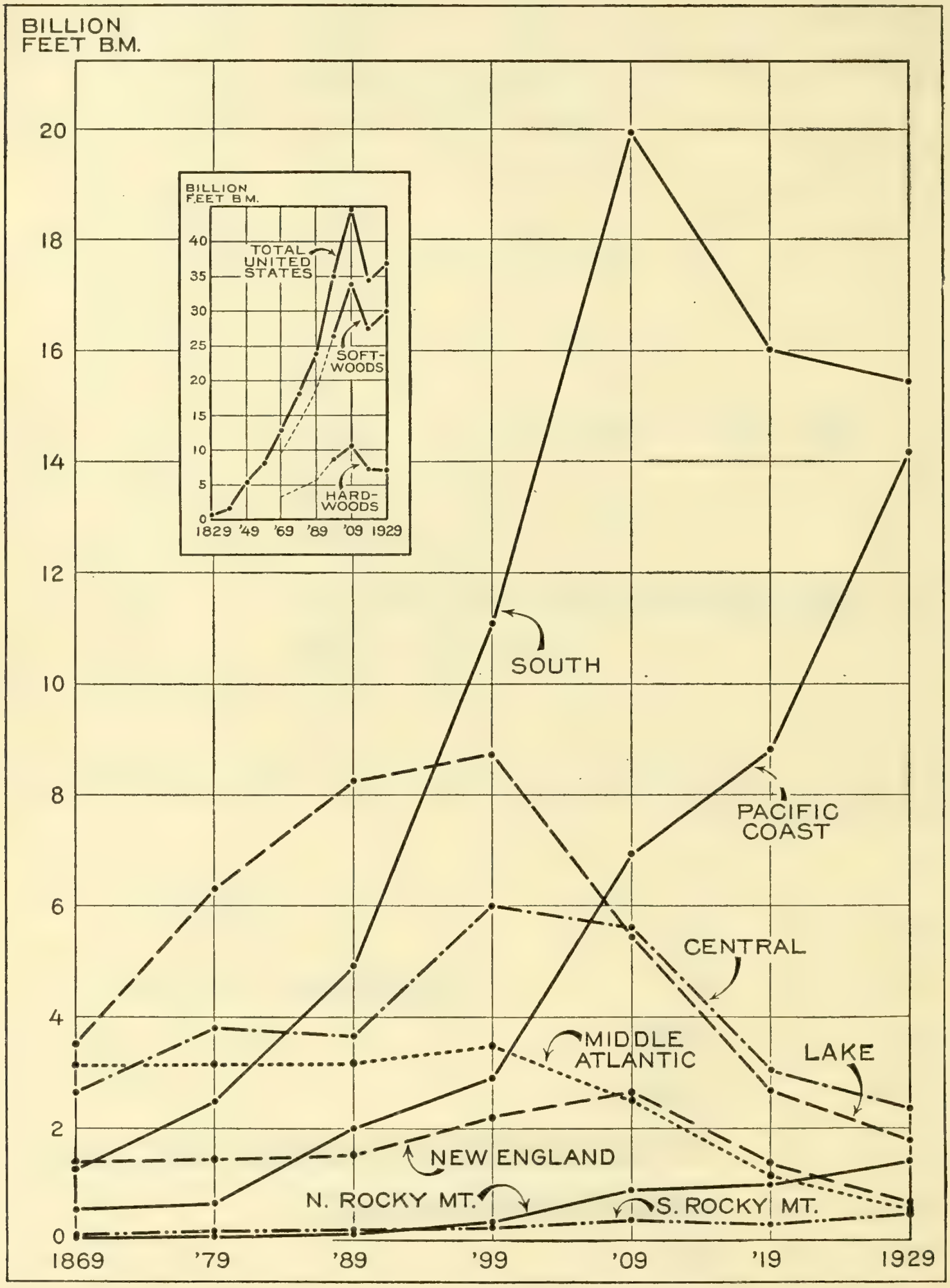

FIGURE 16.—Lumber production in the United States by regions 1869–1929.

The fact that lumber has long been our most important timber product is significant. It points to production of saw-timber as the major object of forest management. This, in turn, means long-rotation ages with all that that implies in complexities of management, particularly in private ownership where in many cases the forest capital is so depleted or so inaccessible as to render long periods of waiting and large expenditures necessary before revenues can commence to come in on a sustained basis and at a rate in keeping with the potential producing capacity of the land.

The present relative distribution of our lumber cut, as well as the historical trend of the cut regionally, is shown by table 14 and figures 15 and 16. The Lake, Central, and Middle Atlantic regions were the most important lumber-producing regions in 1869, and at that time each was cutting 2½ billion board feet or more. The Lake continued prominent, reaching its peak in the early nineties, although surpassed shortly thereafter by the rapidly expanding cut in the South.

TABLE 13.—*Timber cut each year for commodity use in the commercial forests of the United States, by items* [1]

Commodity production					Timber cut (commodity drain) [3]								
Item	Unit	Quantity [2]			Total volume in cubic feet [4]			Saw-timber trees [5]			Cordwood trees [6]		
		Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood
		Thousands	*Thousands*	*Thousands*	*Thousand cubic feet*	*Thousand cubic feet*	*Thousand cubic feet*	*Thousand feet board measure*	*Thousand feet board measure*	*Thousand feet board measure*	*Cords*	*Cords*	*Cords*
Lumber	Foot board measure.[7]	38, 000, 000	30, 957, 920	7, 042, 080	7, 371, 372	5, 668, 700	1, 702, 672	38, 000, 000	30, 957, 920	7, 042, 080	----	----	----
Fuelwood	Cords	61, 266	22, 511	38, 755	4, 002, 635	1, 485, 135	2, 517, 500	7, 047, 000	4, 146, 000	2, 901, 000	27, 723, 840	7, 291, 200	20, 432, 640
Hewed ties	Pieces	53, 215	22, 078	31, 137	633, 034	232, 491	400, 543	2, 025, 165	835, 553	1, 189, 612	----	----	----
Fence posts	do	395, 946	138, 503	257, 443	628, 836	278, 438	350, 398	1, 299, 459	654, 438	645, 021	3, 641, 342	1, 615, 345	2, 025, 997
Pulpwood	Cords	5, 336	4, 726	610	588, 666	521, 908	66, 758	1, 473, 620	1, 316, 815	156, 805	2, 084, 080	1, 827, 120	256, 960
Mine timbers (round).	Cubic feet	184, 875	37, 509	147, 366	231, 780	47, 530	184, 250	155, 988	43, 626	112, 362	1, 692, 152	325, 437	1, 366, 715
Veneer logs	Foot board measure.[8]	920, 034	293, 882	626, 152	230, 607	59, 601	171, 006	1, 033, 708	332, 691	701, 017	----	----	----
Slack staves	Pieces	979, 610	360, 970	618, 640	109, 345	33, 863	75, 482	487, 861	179, 780	308, 081	----	----	----
Slack heading	Sets	67, 766	43, 310	24, 456	42, 452	24, 701	17, 751	203, 016	129, 737	73, 279	----	----	----
Slack hoops	Pieces	138, 939	----	138, 939	10, 053	----	10, 053	41, 626	----	41, 626	----	----	----
Logs and bolts in manufactures.	Foot board measure.[8]	593, 328	92, 393	500, 935	156, 575	20, 790	135, 785	677, 960	109, 443	568, 517	----	----	----
Tight staves	Pieces	307, 167	149, 921	157, 246	97, 116	39, 414	57, 702	460, 378	224, 822	235, 556	----	----	----
Tight heading	Sets	26, 609	9, 888	16, 721	43, 733	13, 047	30, 686	199, 372	74, 138	125, 234	----	----	----
Shingles	Pieces	6, 298, 100	6, 298, 100	----	138, 558	138, 558	----	629, 810	629, 810	----	----	----	----
Export logs and hewn timbers.	Foot board measure.[8]	307, 570	289, 670	17, 900	60, 514	55, 611	4, 903	340, 535	320, 503	20, 032	----	----	----
Poles	Pieces	3, 443	2, 790	653	37, 571	31, 894	5, 677	149, 374	131, 859	17, 515	43, 679	31, 955	11, 724
Distillation wood	Cords	1, 283	434	849	36, 367	4, 294	32, 073	88, 970	11, 300	77, 670	204, 870	22, 600	182, 270
Piling	Pieces	1, 363	912	451	28, 978	21, 125	7, 853	141, 527	108, 497	33, 030	13, 866	13, 205	661
Tanning extract wood.	Cords	418	----	418	26, 173	----	26, 173	118, 950	----	118, 950	37, 600	----	37, 600
Excelsior wood	do	179	58	121	20, 943	6, 786	14, 157	67, 125	21, 750	45, 375	44, 750	14, 500	30, 250
Total, all items.	----	----	----	----	14, 495, 308	8, 683, 886	5, 811, 422	54, 641, 444	40, 228, 682	14, 412, 762	35, 486, 179	11, 141, 362	24, 344, 817

[1] Based upon the average quantity of commodities produced from domestic timber during the years 1925 to 1929, inclusive, as shown under "commodity production."

[2] Estimated number of units produced for each item listed, excluding production from sawmill waste and imported logs, but including production from logging waste as well as from noncommercial forests. Items in cords include the bark in large part. Basic data from reports of the Census of Manufactures, the Forest Service, and information supplied by State and commercial organizations.

[3] Includes only the timber cut on commercial forest areas. The quantities were computed by converting the "commodity production" quantities into terms of "timber cut". Allowance was made for the fact that some items, including fuel-wood, posts, pulpwood, distillation wood and tanning extract material, are produced partly from so-called logging waste; and fuel-wood, ties, posts, mine timbers and poles partly from timber grown on noncommercial areas.

[4] Total quantity of timber cut from the commercial forests, including both saw-timber and cordwood trees. The volumes, necessarily shown in cubic feet, include the tops (cordwood size and larger) of the softwood saw-timber trees, and the tops and limbs of the hardwood saw-timber trees. Bark is not included.

[5] Includes only timber of saw-timber size. The volumes, in board feet, are equivalent to the lumber which could have been sawed from such trees.

[6] Includes only the merchantable volume, in cords, of trees below saw-timber size, in saw-timber, cordwood, and restocking areas.

[7] Lumber tally measure.

[8] Log scale measure.

TABLE 14.—*Lumber production in the United States by regions, 1869–1929* [1]

[Million feet board measure]

Year	All regions	New England	Middle Atlantic	Lake	Central	South	Pacific Coast	North Rocky Mountain	South Rocky Mountain
1869	12, 756	1, 401	3, 156	3, 592	2, 698	1, 288	558	14	49
1879	18, 091	1, 460	3, 187	6, 278	3, 821	2, 498	664	39	144
1889	23, 842	1, 527	3, 198	8, 251	3, 714	4, 847	2, 028	117	160
1899	35, 078	2, 204	3, 506	8, 750	6, 011	11, 116	2, 901	321	269
1909	44, 510	2, 668	2, 529	5, 476	5, 625	19, 973	6, 916	954	369
1910	40, 018	1, 969	1, 985	5, 030	4, 752	17, 432	7, 448	1, 065	337
1911	37, 003	1, 863	1, 772	4, 714	4, 298	15, 965	7, 087	994	310
1912	39, 158	1, 981	1, 732	4, 424	4, 387	18, 118	7, 239	986	291
1913	38, 387	1, 672	1, 425	3, 866	3, 953	18, 312	7, 893	1, 011	255
1914	37, 346	1, 966	1, 587	3, 918	3, 634	17, 801	7, 082	1, 081	277
1915	37, 012	2, 115	1, 660	3, 410	3, 705	17, 980	6, 770	1, 105	267
1916	39, 807	1, 823	1, 292	4, 050	3, 336	19, 617	8, 136	1, 233	320
1917	35, 831	1, 462	1, 026	3, 525	2, 683	17, 165	8, 570	1, 110	290
1918	31, 890	1, 412	961	3, 220	2, 513	13, 775	8, 590	1, 143	276
1919	34, 552	1, 418	1, 166	2, 692	3, 038	16, 078	8, 818	1, 053	289
1920	33, 799	1, 138	1, 060	2, 386	2, 754	14, 362	10, 355	1, 380	364
1921	26, 961	1, 029	768	1, 647	1, 793	13, 530	7, 215	757	222
1922	31, 569	790	634	1, 944	1, 772	14, 383	10, 581	1, 161	304
1923	37, 166	941	690	2, 392	2, 059	16, 462	12, 762	1, 500	360
1924	35, 931	944	675	2, 338	2, 054	16, 239	11, 930	1, 368	383
1925	38, 339	872	635	2, 445	1, 985	17, 148	13, 287	1, 529	438
1926	36, 936	834	575	2, 047	2, 001	15, 571	14, 189	1, 326	393
1927	34, 332	722	509	1, 795	1, 846	14, 476	13, 389	1, 320	475
1928	34, 142	766	445	1, 803	1, 677	13, 978	13, 630	1, 365	478
1929	36, 886	678	554	1, 771	2, 368	15, 462	14, 149	1, 418	486

[1] Statistics reported by the Bureau of the Census and the Forest Service.

On the whole, the Lake, Middle Atlantic, and Central regions, with lesser contributions from New England which did not reach its peak in lumber cut until 10 years later, continued to supply the major part of the Nation's lumber cut until about 1899, at which time their combined cut not only commenced to fall off in itself but even more rapidly in relation to the rapidly expanding cut in the South. By 1929 all three were below the 2½ billion mark. The South reached its peak of 20 billion board feet about 1909 at which time it was supplying nearly half the cut for the entire country. Since that time it has rather slowly fallen off but in 1929 it was still slightly in excess of the Pacific Coast cut, which assumed significant proportions soon after 1909 and has mounted rapidly since then. Considering the relatively large supply of virgin timber in the Pacific Coast as compared with that of the South and the depleted condition of the growing stock as a whole in the South, it seems not only very probable, but also desirable, viewed from the aspect of rehabilitating and organizing on a sustained yield basis the latter's forest capital, that the cut of lumber in the Pacific Coast region should assume and hold the regionally predominant position for a limited period of time. Our domestic supply of hardwoods, however, must continue to come from the forests of the East and South, for western forests are practically all softwoods.

FUEL WOOD

The average yearly production of forest fuel wood in the period 1925–29 is shown to be 61 million cords (table 13), of which about 42 million cords are charged as drain on the commercial forests. The drain on cordwood stands is estimated to be 28 million cords, and that on saw-timber stands the equivalent of 14 million cords.

Quantitatively, fuel wood, comprising 13 percent of the saw timber cut and 28 percent of the total cut, is second in importance among forest commodities. However, since it is the least exacting so far as technical specifications or qualities are concerned, it is, of all the major commodities, the one that can best be furnished by improvement cuttings in both cordwood and saw-timber stands, or by the salvaging of waste in logging. In most European countries fuel wood is supplied in these ways and so made a means of improving the forest. In the United States the bulk of the fuel wood drain is still either from saw-timber trees or smaller trees which theoretically should be left to produce saw timber.

Fuel wood is a relatively bulky, low-value commodity, and therefore not adapted to bear the cost of long transportation. Thus it is at a disadvantage in competition with other fuels, especially in the urban communities. Quantitatively, the regional fuel wood cut corresponds more closely with regional population than that of any other major timber commodity.

On the whole, statistics on fuel wood cut (and consumption) are hardly satisfactory, and there may be a considerable percentage of error in those presented. Those available, together with common knowledge of the increasing use of other fuels, particularly in the urban centers, indicate a sizable falling off in the fuel wood cut in recent years.

HEWED TIES

In amount of timber drain, hewed ties rank third, although falling far short of either lumber or fuel. This cut, amounting to over 2 billion board feet annually, is considered as coming entirely from saw timber. Both hardwoods and softwoods are used. The great bulk of the hewed-tie cut comes from the South; more, in fact, than from all the rest of the country.

FENCE POSTS

The amount of timber cut annually for round and split fence posts approximates that for hewed ties, but unlike that for ties, the drain falls only in part on saw timber. The South furnishes the great bulk of the fence-post cut.

PULPWOOD

The pulpwood cut approximates quantitatively that for hewed ties and for fence posts. It comes both from saw timber and cordwood—the greater bulk from the former. Regionally the Lake States and New England each supply 28 percent, the South 17 percent, the Pacific Coast 12, the Middle Atlantic 11, and the Central 4 percent. The pulping properties required in pulpwood are such that a limited number of species, such as spruce, fir, hemlock, aspen, etc., have come to be known as standard pulpwood species. The particular properties of such species are further associated with individual processes of pulp manufacture. Pulpwood supplies must be in geographic or economic proximity to pulp and paper plants that involve large investments and are not easily moved, or else the domestic supplies lose out in competition with foreign (especially Canadian) supplies.

Theoretically there are vast quantities of pulpwood available in this country. Actually drain has proceeded so nearly to the point of exhaustion of the economically accessible and suitable local supplies, when compared with the cost of foreign supplies, that more than half of the pulpwood, wood pulp, and paper supplies of the country are at present obtained from other countries. The pulpwood drain and its relation to the forest supplies of the United States, in short, constitutes a highly complicated and important subject, aspects of which are treated elsewhere in this section and in the section on Our National Timber Requirements.

TIMBER LOSSES

Forest losses resulting from forest fires, insects, disease, naval-stores operations, drought, and wind amount to about 1,800 million cubic feet per year, or about 4¾ billion board feet in saw-timber trees and about 11 million cords in cordwood trees. (Table 10.) Much of this loss is caused by fires that might have been prevented or checked, and by epidemics of insects and disease, the ravages of which in many instances could have been greatly modified under a more effective system of forest management.

FIRE LOSSES

Timber killed annually by fire and not utilized during the years 1925 to 1929, inclusive, is estimated at over 870 million cubic feet, about a third of which is in saw-timber trees. (Table 15.) Fire losses in trees of saw-timber size amount to nearly 1,400 million board feet, and in trees of cordwood size to nearly 7 million cords.

TABLE 15.—*Timber killed each year by fire and not utilized (fire loss) in the commercial forests of the United States, by character of growth and region*[1]

Region	All timber			Saw-timber trees			Cordwood trees		
	Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood
	M cu ft.	*M cu. ft.*	*M cu. ft.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*Cords*	*Cords*	*Cords*
New England	14, 515	4, 041	10, 474	2, 370	834	1, 536	149, 963	40, 621	109, 342
Middle Atlantic	52, 111	13, 463	38, 648	7, 171	1, 822	5, 349	561, 327	144, 622	416, 705
Lake	63, 011	20, 201	42, 810	3, 740	895	2, 845	782, 734	221, 224	561, 510
Central	87, 153	8, 007	79, 146	12, 050	985	11, 065	937, 777	85, 873	851, 904
South	294, 756	196, 634	98, 122	395, 314	276, 824	118, 490	2, 373, 504	1, 641, 241	732, 263
Pacific Coast	182, 022	182, 022	-------	563, 549	563, 549	-------	902, 822	902, 822	-------
North Rocky Mountain	172, 829	172, 829	-------	392, 944	392, 944	-------	1, 177, 243	1, 177, 243	-------
South Rocky Mountain	4, 293	4, 293	-------	13, 095	13, 095	-------	18, 348	18, 348	-------
Total	870, 690	601, 490	269, 200	1, 390, 233	1, 250, 948	139, 285	6, 903, 718	4, 231, 994	2, 671, 724

[1] Based upon the quantity of timber killed and not utilized, 1925 to 1929, inclusive.

These losses do not include the damage done to the trees that survive. Nor do they include the destruction of young growing stock below cordwood size, which is a far more formidable loss and one which is largely responsible for the very unsatisfactory regrowth conditions, especially in the poor and nonrestocking areas. Fire, which accompanies destructive methods of logging, has, through repeated burning of young trees and complete destruction of saplings and seedlings, been responsible primarily for the deterioration or devastation of immense areas of forest land, and has been an outstanding factor in keeping the forest growth of the United States below the current drain upon our timber.

Fire and timber cutting, of course, not infrequently work together with their separate effect difficult to determine. Either one can cause forest deterioration or devastation. The difference between the two conditions is one of degree rather than kind. The bulk of the damage, however, is the result of fire after cutting. Only rarely does logging, no matter how carried on, alone result in devastation, but the resulting accumulation of highly inflammable slash invites fires. A single fire in such debris may and frequently does destroy all young growth and trees of seed-bearing size, leaving the area incapable of restocking by natural means. This phase of the forest problem is discussed under Progress in Forestry and Existing Plans in the section "Current Forest Devastation and Deterioration."

It is noteworthy that of the more than 40 million acres burned annually (1926-30 period) 90 percent was in the South, and that half of this was in two States. Although the area of unprotected land included in these figures represents an exceedingly rough estimate, it is certain that the great bulk of fire damage in terms of area burned over occurred on lands which had not been placed under organized fire protection. According to data available for 1930, 90 percent of the total area burned in that year was land not so protected. In the entire protected area the acreage burned was 1.4 percent of the total whereas the corresponding figure for the unprotected area was about 20 percent. These figures alone show that forest fire can be controlled, and they indicate the importance of extending organized fire protection to the still unprotected land.

INSECTS, DISEASE, WIND, AND DROUGHT

Timber killed annually by disease, insects, wind, naval-stores operations, and drought, and not utilized, during the years 1920 to 1929, inclusive, amounted to over 985 million cubic feet, including 592 million in saw-timber trees and 393 million in cordwood trees. (Table 16.) Losses in trees of saw-timber size amounted to nearly 3½ billion board feet, and in smaller trees to over 4 million cords.

TABLE 16.—*Timber killed each year by disease, insects, drought, wind, etc., and not utilized in the commercial forests of the United States, by character of growth and region* [1]

Region	All timber			Saw timber trees			Cordwood trees		
	Total	Softwood	Hardwood	Total	Softwood	Hardwood	Total	Softwood	Hardwood
	M. cu. ft.	*M. cu. ft.*	*M. cu. ft.*	*M. ft. b.m.*	*M. ft. b.m.*	*M. ft. b m.*	*Cords*	*Cords*	*Cords*
New England	72, 348	65, 113	7, 235	254, 600	229, 140	25, 460	247, 820	223, 032	24, 788
Middle Atlantic	11, 374	-------	11, 374	14, 155	---------	14, 155	91, 244	---------	91, 244
Lake	13, 524	3, 530	9, 994	35, 263	6, 849	28, 414	54, 634	12, 414	42, 220
Central	109, 088	2, 916	106, 172	59, 248	1, 452	57, 796	1, 072, 164	28, 713	1, 043, 451
South	298, 899	145, 576	153, 323	711, 126	510, 073	201, 053	1, 899, 083	761, 850	1, 137, 233
Pacific Coast	324, 599	324, 599	-------	1, 748, 664	1, 748, 664	-------	371, 711	371, 711	---------
North Rocky Mountain	106, 309	106, 309	-------	474, 550	474, 550	-------	94, 910	94, 910	---------
South Rocky Mountain	49, 068	49, 068	-------	104, 556	104, 556	-------	249, 796	249, 796	---------
Total	985, 209	697, 111	288, 098	3, 402, 162	3, 075, 284	326, 878	4, 081, 362	1, 742, 426	2, 338, 936

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[1] Based upon the volume of timber killed and not utilized, 1920 to 1929, inclusive. This estimate does not include normal losses that are constantly occurring in the forest but only large-scale or cataclysmic destruction. Data compiled in cooperation with the Bureau of Entomology, and the Division of Forest Pathology, Bureau of Plant Industry, U.S. Department of Agriculture.

Against the various causes of these losses science is waging relentless warfare. Forest entomologists have made notable progress in devising methods for checking forest insect depredations, and in working out control measures. Similarly, forest pathologists have made notable progress against the inroads of disease. These two phases of the forest problem, as well as that of forest-fire prevention and control, are discussed in sections, "Progress in Forest Pathology" and "Progress in Forest Entomology", under "Progress in Forestry and Existing Plans"; also in sections, "Protection Against Fire", "Protection Against Forest Insects", and "How to Stop Forest Devastation", under "National Programs Required and the Responsibility for Them."

TIMBER GROWTH

Growth is the characteristic which renders a forest, unlike a mine, susceptible to use and replacement on a permanently productive basis. Continued removal of timber without regard to or in excess of replacement by growth must sooner or later bring about the deterioration of the forest far below its producing capacity, if not its complete destruction. Such treatment of forests has been aptly described as timber mining. In an analysis of forest resources, therefore, a fundamental consideration is that of present and potential growth and of the relation between growth, drain through cutting and through losses by fire and other causes, and timber requirements. (See preceding subsection, "Forest Drain", and following section, "Our National Timber Requirements").

CURRENT ANNUAL GROWTH

The best available data on growth—though employed, as in the present discussion, with due consideration of age classes, density of stocking, mixture of species, site differences, and other factors that affect the rate of growth—afford a basis only for rough estimates of growth rates for the various forest types. Nevertheless, it is believed that the estimates and relationships presented and the inferences drawn therefrom are in the main dependable.

Table 17 gives the estimated present current annual growth in the United States as a whole of material large enough for saw timber, as well as that of all timber of usable size including both saw timber and cordwood. The estimates are for net growth, after allowing for so-called "normal" losses from decay, insects, etc. Abnormal or unusual losses from disease or insect epidemics, fires, hurricanes, etc., are taken care of in the estimates of drain. The growth in board feet consists of the growth on the present saw-timber stands, after deducting the growth on the saw-timber cut during the year and adding the total saw-timber volume on that portion of the cordwood area which passes into the saw-timber class each year. In the same way, the total growth on cordwood and saw-timber areas combined, expressed in cubic feet, consists of the net growth on stands remaining after the year's cut, plus the total volume on the restocking areas which pass into the cordwood class annually.

TABLE 17.—*Present current annual growth of usable material on commercial forest areas of the United States, by regions* [1]

Region	Combined saw-timber and cordwood growth			Saw-timber growth		
	Total	Softwood	Hard-wood	Total	Softwood	Hard-wood
	Million cubic feet	*Million cubic feet*	*Million cubic feet*	*Million feet board measure*	*Million feet board measure*	*Million feet board measure*
New England	427	162	265	764	410	354
Middle Atlantic	634	114	520	575	172	403
Lake	644	167	477	116	12	104
Central	1,128	83	1,045	727	41	686
South	4,784	2,994	1,790	6,799	4,946	1,853
Pacific Coast	680	675	5	1,785	1,765	20
North Rocky Mountain	416	416		576	576	
South Rocky Mountain	199	199		389	389	
Total	8,912	4,810	4,102	11,731	8,311	3,420

[1] Exclusive of Alaska. Growth figures represent volume of wood without bark, as in estimates of timber stand and drain. Board-foot volumes are on the basis of estimated lumber tally, assuming utilization consistent with good practice in each region. The growth in cubic feet is for stem wood, including all trees 4 inches or more in diameter breast height; it includes the limbs in the hardwoods.

Of nearly 12 billion board feet of saw-timber growth, over 70 percent is softwood. Of the total growth of almost 9 billion cubic feet, softwood comprises over 50 percent. More than one half of the saw-timber growth and also of the total growth is in the South, which has more than half of its forest area, or about 100 million acres, in growing saw timber and cordwood. The growth in the Lake region, especially for softwood, is strikingly low, owing primarily to the depletion of the stock of saw timber and cordwood; only one fifth of the 56 million acres of forest land bears growing saw timber or cordwood, and the remainder is classed either as restocking with trees below cordwood size, or as nonrestocking.

The comparatively low figures for growth in the West—about one seventh of the country's total for all growth, and less than one fourth for saw timber—are explained by the fact that much of the forest land in the West is covered with overmature timber which is making little or no net growth, and a large portion of the remainder is either deforested or covered with small reproduction. Moreover, the growth rates are generally low in the Rocky Mountain regions.

THE RELATION OF CURRENT GROWTH TO DRAIN

A simple comparison of current growth and drain means very little except as the quantity of surplus old growth, the extent, location, and condition of growing stock, and other pertinent factors are taken into consideration. The national ratios of 5 to 1 for drain and growth of material of saw-timber size, and of nearly 2 to 1 for material of saw-timber and cordwood size combined, are the net results of widely differing conditions which operate broadly to divide the whole country into three major growth sections. Table 18 shows regional growth and drain estimates combined by the regional groups within each of which the conditions in general are fairly similar. (See also figures 20 and 21.) It also shows, for comparison with drain, as a matter of importance, the saw-timber cut for lumber.

TABLE 18.—*Current annual growth and drain (1925–29 basis)*

Region	Combined saw timber and cordwood			Saw timber			
	Growth	Drain	Ratio, drain to growth	Growth	Drain	Ratio, drain to growth	Saw timber cut for lumber
	Million cubic feet	*Million cubic feet*		*Million feet board measure*	*Million feet board measure*		*Million feet board measure*
New England	427	706	1.7	764	1,905	2.5	783
Middle Atlantic	634	835	1.3	575	1,083	1.9	537
Total	1,061	1,541	1.5	1,339	2,988	2.2	1,320
Lake	644	1,343	2.1	116	2,748	23.7	1,997
Central	1,128	2,263	2.0	727	5,525	7.6	2,452
South	4,784	7,012	1.5	6,799	26,339	3.9	16,672
Total	6,556	10,618	1.6	7,642	34,612	4.5	21,121
Pacific Coast	680	3,444	5.1	1,785	18,799	10.5	13,693
North Rocky Mountain	416	566	1.4	576	2,378	4.1	1,405
South Rocky Mountain	199	182	0.9	389	657	1.7	461
Total	1,295	4,192	3.2	2,750	21,834	7.9	15,559
All regions	8,912	16,351	1.8	11,731	59,434	5.1	38,000

At one extreme are the western regions, particularly the Pacific Coast. In the West the drain is shown to be about eight times the growth for saw timber and more than three times the saw-timber and cordwood growth combined. This situation is largely explained, and also justified, by the existence of large quantities of overmature timber in the West which are making no net growth, but which may logically be drawn upon for some time to supply a considerable share of the Nation's needs for lumber. To just what extent and for what period this is true will depend in part upon the proportion of the old growth which may prove economically available. It will also be influenced by the extent to which cut-over areas are promptly and adequately restocked and protected. Lumber is the chief saw-timber product of the West which in large quantity can stand the cost of transportation to distant regions. It is natural, therefore, that lumber should account for a larger proportion of saw-timber drain in the West—over 70 percent—than in either of the other regional sections.

In the New England and Middle Atlantic regions is a very different situation. Here the old-growth stands with which excessive drain might be offset are New England hardwoods of poor quality and doubtful accessibility. Consequently, a saw-timber growth less than half the current saw-timber drain—even if it is slightly larger than the current cut for lumber—and an all-timber growth that is only two thirds of the total drain, represent a condition far less favorable locally than that indicated by the greater ratios in the West. Progressive depletion is still under way in both the New England and Middle Atlantic regions.

Most dangerous of all is the situation in the Lake-Central-South section, which comprises 310 million acres or 63 percent of our commercial forest land and a similarly large proportion of the country's timber producing potentialities. Here, it is true, high growth capacity per acre in most of this territory and relative proximity to large consuming centers, broadly speaking, constitute especially favorable factors for the practice of forestry. But, on the other hand, because of the practical exhaustion of old-growth supplies and the large proportion of the area with growth below cordwood size or with none at all, the high ratios of drain to growth—4.5 to 1 for saw timber and 1.6 to 1 for all timber—signify a progressive impoverishment of a forest capital or growing stock already seriously depleted. Consequently, it would appear that the welfare of the forest resources—with saw timber the main object of management—can only be safeguarded by a drastic reduction in saw-timber drain in the Lake-Central-South section. Indeed, as will be shown later, a substantial reduction in the lumber cut below that for the 1925–29 period appears to be inevitable.

THE SIGNIFICANCE OF RECENT TRENDS TO FUTURE GROWTH

It is, of course, impossible to forecast all the factors that will influence future growth totals, even by 1950, and no attempt will be made to do so. The growth figures in table 19 are in no way intended as a forecast. The effect of certain assumptions as to fire protection and drain can, however, be roughly estimated. Better fire protection, and insect and disease control, would tend to hasten the restocking of cut-over areas, and to increase growth in all classes of stands. Twenty years, however, is too short a period for such improvements to have much effect upon annual growth of saw timber and cordwood. Moreover, it is wholly unlikely that abnormal losses from fire or other causes will be wholly eliminated.

TABLE 19.—*Estimated possible current annual growth and average annual drain as of 1950 compared to those on present commercial forest areas* [1]

Region	1925–29 rate of drain		Assumed average annual drain 1930–50		Growth on combined saw timber and cordwood		Growth on saw timber	
	Total	Saw timber	Total	Saw timber	1930	1950	1930	1950
	Million cu. ft.	*Million ft. b. m.*	*Million cu. ft.*	*Million ft. b. m.*	*Million cu. ft.*	*Million cu. ft.*	*Million ft. b. m.*	*Million ft. b. m.*
New England	706	1, 905	350	950	427	470	764	890
Middle Atlantic	835	1, 083	420	540	634	760	575	1, 050
Total	1, 541	2, 988	770	1, 490	1, 061	1, 230	1, 339	1, 940
Lake	1, 343	2, 748	670	1, 400	644	740	116	270
Central	2, 263	5, 525	1, 120	2, 800	1, 128	1, 170	727	410
South	7, 012	26, 339	3, 500	13, 170	4, 784	6, 460	6, 799	7, 430
Total	10, 618	34, 612	5, 290	17, 370	6, 556	8, 370	7, 642	8, 110
Pacific Coast	3, 444	18, 799	3, 440	18, 800	680	530	1, 785	1, 850
North Rocky Mountain	566	2, 378	570	2, 400	416	420	576	480
South Rocky Mountain	182	657	180	700	199	200	389	440
Total	4, 192	21, 834	4, 190	21, 900	1, 295	1, 150	2, 750	2, 770
All regions	16, 351	59, 434	10, 250	40, 760	8, 912	10, 750	11, 731	12, 820

[1] Based on arbitrary assumptions as to drain.

Cutting in the East at whatever rate in excess of annual growth would tend to restrict future growth by depleting the growing stock capable of producing merchantable material. Severe drain upon the cordwood stands would limit the acreage advancing from cordwood to saw timber and therefore reduce the saw-timber growth. The degree to which cutting is made in accordance with good silvicultural practices also has a distinct bearing upon growth. Such practices would tend to increase total yields and at the same time build up the growing stock in the cordwood and younger age classes.

The factor of greatest weight and uncertainty is that of drain—its value, character, location, etc. Although the estimated current annual growth for 1950 given in table 19 is in no sense a prediction of what will actually transpire, an effort has been made to select assumptions as to drain which might conceivably be realized, taking into account the effect of the present depression, the bearing of limited usable supplies in the eastern forest regions, and the possibilities for constructive forestry measures. For all the eastern regions the drain for the period from 1930 to 1950 was assumed at an average rate equal to one half the 1925–29 drain. Because of the severe depletion of growing stock which has already taken place in these regions a continuation of the 1925–29 drain seems impossible. The current low ebb of lumber production, which is probably less than half the 1925–29 rate, probably will be followed by a period of increased production before the exhaustion of suitable saw-timber supplies forces a protracted restriction in the cut, especially in the Lake-Central-South section. Some students of the situation believe that by 1950 the saw-timber drain in the East is likely to be less than half the 1925–29 rate, but an average of one half for the two decades appears to be a reasonable assumption as a basis for this calculation. On the other hand, because of the large reservoir of old-growth stumpage, there seems to be no reason, with favorable economic conditions, why the 1925–29 rate of drain in the West as a whole may not be continued until 1950.

With these assumptions as to drain, forest conditions which might obtain in 1950 were projected. The stands in each region, as of 1930, were reduced at the assumed average rates of drain for the 20-year period. Growth was allowed on all stands until the theoretical time of cutting. An estimate based on the growth rate and age classes was then made of the area and volume of cordwood stands which would reach saw-timber size by 1950, the theoretical amount which might so mature being reduced by the area which would be cut over as cordwood. In a similar manner, the amount of restocking land which would advance to cordwood size was estimated. With the distribution of growth classes and the corresponding volumes of standing timber in 1950 set up in this way, the theoretical current annual growth at that time was calculated by the same method used for present current growth.

Of special importance is the comparison, shown in table 19, of current growth as of 1950 with current 1930 growth both for saw timber, and for saw timber and cordwood combined, and also with the assumed reduced drains. For the New England and Middle Atlantic regions together the 1950 growth rates of both saw timber, and saw timber and cordwood combined, would increase, and would exceed the assumed average drains. In the Lake-Central-South section, on the other hand, the growth of saw timber alone would remain about as at present and also at less than one half of the assumed average drain. The combined saw timber and cordwood growth, however, would exceed the present growth and also the assumed average drain. The disparity between growth and drain for saw timber in the Lake and Central regions is particularly striking. These estimates indicate that, from the standpoint of saw-timber production, even an average drain of only 50 percent of the 1925–29 rate would still further reduce an already severely depleted growing stock in the Lake, Central, and South regions. In the western group the rates of growth in comparison with drain would remain much the same as for 1925–29.

Of equal importance from the standpoint of the forest situation in 1950 is a consideration of the areas of age classes and of the stands of timber, in comparison with the present. The possible distribution of age-class areas in 1950 in comparison with 1930 is shown in figure 17, excluding 63 million acres that probably will not produce commercially valuable saw-timber stands within the period required for existing growth, if any, to mature. Assuming reasonably efficient fire protection, the areas of restocking land might increase nationally from the present 123 million to perhaps 160 million acres. In arriving at this figure prompt restocking of lands cut over was assumed. The cordwood area might increase from 121 to something like 135 million acres, with a more or less proportionate increase in volume. Of greater interest and concern, however, are the estimated

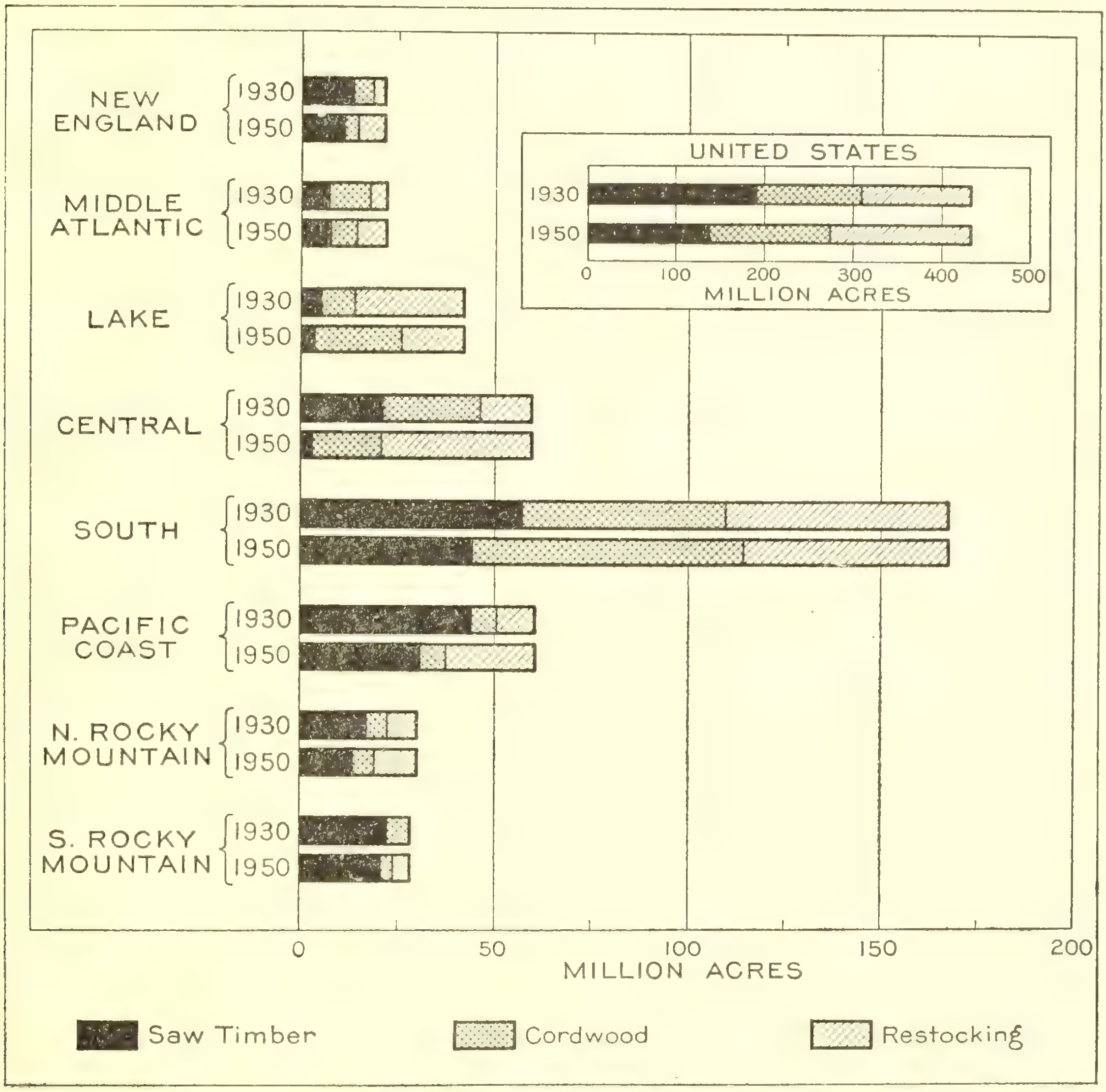

FIGURE 17.—Present distribution of forest areas and their estimated distribution in 1950, by regions. The 1950 estimate is based on the 1925–29 average drain in the West, and in the East on half the 1925–29 drain. Present devastated areas, estimated at 63 million acres, not included.

trends as to areas and volumes of saw timber. Table 20 shows in a summarized way these two features. Figure 18 compares possible 1950 volumes with the present. Under the assumptions made, reductions both in saw-timber areas and in saw-timber volume would probably be marked. These apparent reductions in saw-timber area could be minimized by a general adoption of silviculturally desirable selective cutting.

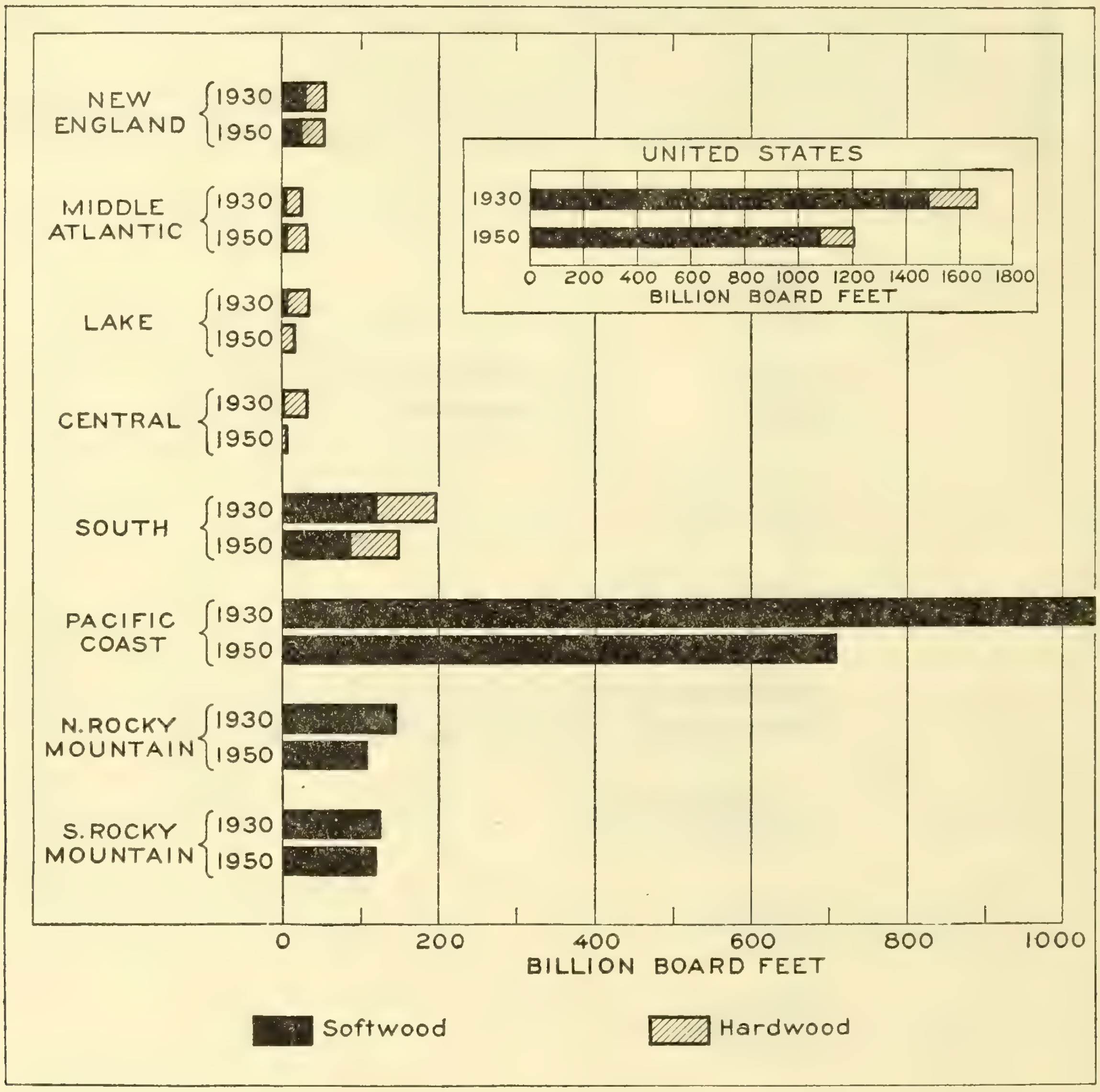

FIGURE 18.—Present volume of hardwood and softwood saw timber and the estimated volume in 1950, by regions. The 1950 estimate is based on the 1925–29 average drain in the West, and in the East on half the 1925–29 drain.

The reduction in saw-timber areas would be most noticeable in the Lake, Central, and Pacific Coast regions. The reduction in saw-timber volume would be very largely in the Pacific Coast region. Actual depletion, however, would be most severe in the Lake and Central regions where the supplies of softwood saw timber would be practically exhausted. This means that in these two regions paucity of supply would force a still greater reduction in saw-timber drain than that assumed in this calculation.

Table 20.—*Estimated possible areas and volumes of saw timber in 1950 on basis of 1925–29 drain continuing in the West and one half 1925–29 drain in the East*

Region	Annual saw-timber drain		Saw-timber area		Saw-timber volume	
	1925–29 rate	Assumed rate 1930–50	1930	1950	1930	1950
	Billion ft. b.m.	*Billion ft. b.m.*	*Thousand acres*	*Thousand acres*	*Billion ft. b.m.*	*Billion ft. b.m.*
New England	1. 90	0. 95	13, 860	10, 990	57. 87	57. 37
Middle Atlantic	1. 08	0. 54	7, 294	7, 921	26. 15	34. 81
Lake	2. 75	1. 40	5, 095	3, 669	35. 88	18. 59
Central	5. 52	2. 80	21, 224	2, 996	34. 62	5. 72
South	26. 34	13. 17	57, 265	44, 065	199. 30	150. 19
Pacific Coast	18. 80	18. 80	44, 140	30, 954	1, 041. 63	710. 78
North Rocky Mountain	2. 38	2. 40	17, 026	13, 808	146. 39	109. 12
South Rocky Mountain	. 66	. 70	22, 741	21, 463	125. 96	120. 66
Total	59. 43	40. 76	188, 645	135, 866	1, 667. 80	1, 207. 24

What the effect would be of continuing the 1925–29 rate of saw-timber drain in the West depends upon a number of factors. Chief among these is the extent to which the remaining stands of old growth will prove to be economically available. It also depends upon the extent to which cutting is made in accordance with the dictates of good silvicultural and forest regulation principles. For example, greater recourse to partial or selective cutting would be advantageous. Although something far short of the ideal will be obtained in allocation and method of cutting, it seems reasonable, in the light of increasing economic availability, that the 1925–29 drain should continue until at least 1950. The indications are, however, that a marked increase in this rate of drain or even indefinite prolongation of it would reduce the growing stock below the amount required for permanent continuation of such production.

In brief, it appears that a continuation of the 1925–29 drain is feasible in the West but that it would be disastrous to the welfare of the forests and the forest industries in the East, unless the best data now available prove later to have been greatly in error. A 50 percent reduction in the average drain to 1950 theoretically might stabilize the situation on that level in the New England and Middle Atlantic regions. In the other eastern regions a greater proportionate reduction may be necessary to prevent further impoverishment of the already depleted growing stocks. Additional measures will probably be needed to rehabilitate these growing stocks.

To look beyond 1950 in the matter of areas of age classes and volumes of standing timber amounts to little more than a guess. However, the effort to do so may help to correct some misunderstandings. It is sometimes stated that the increasing shortage of saw-timber stands in the East will be offset in a few decades without any particular human effort by a huge wave of second growth reaching saw-timber size. Such a wave appears to be in prospect in the Lake States after 1950, but it is doubtful if the saw-timber growth will rise much above 1 billion board feet per year. A similar increase in available saw timber may come to pass in the Central region at a still later date but in the meantime saw-timber production in this region may drop to a very low ebb.

Without drastic reduction of drain and the most careful husbanding of sapling, cordwood, and young saw-timber stands, there does not seem to be any prospect of an enlarged volume of available saw timber in the New England and Middle Atlantic regions. At present rapid depletion of cordwood stands is preventing the building up of growing stock of saw-timber size in these two regions. Even with drain at only half the 1925–29 rate the area in the restocking and deforested classes seems likely to increase to nearly half the total forest area of these regions by 1950.

Finally, these calculations afford no evidence that the volume of young growth annually approaching maturity in the South after 1950 will be any greater than the amount maturing annually prior to that time. The figures indicate that the forest situation in this great region may remain without material change for some decades unless forestry measures are aggressively adopted throughout the region.

SUSTAINED YIELD POSSIBILITIES

An underlying purpose in the management of forests is to provide a stable and ample supply of usable timber of the character and quality needed to meet the requirements of the users of wood and wood products. This may apply to a single forest property, to the forests of a region as a whole, or to an entire country. Forests so organized and managed are referred to as being on a sustained-yield basis, and the volume of material present, as the basis for management is known as the growing stock. Under such management the age classes will be more or less evenly distributed.

Where there is a large surplus of mature and overmature timber, as in the Pacific Coast region, the rate of cutting can exceed the growth until the surplus is used up without violating the principle of sustained yield. The cutting of this surplus should, of course, be extended over a sufficient number of years to permit the existing young stands to mature and the cut-over land to restock in a sequence which will permit cutting to continue without interruption. Where there is a serious deficiency in mature timber and timber approaching maturity, as in the East, continued cutting of saw timber in excess of the annual growth must sooner or later exhaust the supply of saw timber that is large enough for economic utilization.

Except for special situations like that on the Pacific coast, a fairly even distribution of age classes is necessary before a volume approximately equal to the annual growth can be permanently cut each year. It is evident, therefore, that there is a close relationship between the volume of growing stock and the volume of usable material that can be cut annually. If we may assume that a forest should be handled on an 80-year rotation for the production of saw timber we may think of such a forest under sustained-yield management as being in the form of eight 10-year groups or age classes, the oldest group affording the usable material for the first 10 years. The next group would reach the age for cutting during the second 10-year period and so on, until at the end of the 80-year rotation the area first cut over would again be ready for cutting. Such a forest contains the minimum growing stock that can supply a continuous cut equivalent to the annual growth on the whole area without, as a rule, necessitating the cutting of timber below the rotation age.

It will be instructive to consider some of the growing-stock aspects of the forests in the several regions in relation to sustained saw-timber yield. The results of theoretical calculations of the yields which might be maintained on three assumptions of regulated growing stock are presented in table 21. The first column is based on a growing stock in which the saw-timber volume equals the volume of present saw-timber stands; the second column upon a growing stock in which the saw-timber volume equals that portion of present saw-timber stands estimated to have a positive utilization value under 1925–29 conditions (see preceding subsection, "Availability of Timber Stands"); the third upon a growing stock in which the saw-timber volume equals the estimated saw-timber volumes in 1950 on the basis set up in table 20.

TABLE 21.—*Estimated saw-timber yields theoretically possible on forests with regular distribution of age classes based on assumed saw-timber volumes*

Region	Basis			Average annual saw-timber drain 1925–29
	Yield based on total 1930 saw-timber volume	Yield based on 1930 saw-timber volumes having positive utilization value	Yield based on estimated 1950 saw-timber volume	
	Million feet b.m.	*Million feet b.m.*	*Million feet b.m.*	*Million feet b.m.*
New England	2, 094	1, 696	2, 121	1. 905
Middle Atlantic	991	702	1, 333	1, 083
Total	3, 085	2, 398	3, 454	2, 988
Lake	1, 374	1, 123	744	2, 748
Central	1, 366	1, 133	229	5, 525
South	9, 186	7, 535	6, 901	26, 339
Total	11, 926	9, 791	7, 874	34, 612
Pacific Coast	26, 041	12, 674	17, 770	18, 799
North Rocky Mountain	2, 928	867	2, 182	2, 378
South Rocky Mountain	2, 519	829	2, 413	657
Total	31, 488	14, 370	22, 365	21, 834
All regions	46, 499	26, 559	33, 693	59, 434

These calculations are premised on an even distribution of age classes, no cutting except for salvage, thinnings and other improvement cuttings, until the saw timber reaches rotation age; and measures adequate to restock cut-over lands and to protect the growing stock. Rotations also are necessarily assumed—60 years for softwoods in the South, 80 years for hardwoods in the South and for all other species in the other eastern regions, 100 years in the Pacific Coast region, and 120 years in the Rocky Mountain regions. For convenient reference table 21 also gives the 1925–29 average saw-timber drain.

These calculations indicate (column 1, table 21) in New England and the Middle Atlantic regions that regulated growing stock with saw-timber volumes equal to present volumes would just about support through sustained yield, a drain of saw timber equal to the 1925–29 rate. This indicated sustained yield exceeds the present annual growth because it assumes no cutting of stands below rotation age other than in cultural operations, whereas under current practices there is a heavy drain in both cordwood and small saw-timber stands, which keeps actual growth of saw timber at a low figure. Even on the basis of the smaller regulated growing stock assumed in the second column a sustained yield of more than two thirds of the 1925–29 saw-timber drain could be maintained.

Regulated growing stock with saw-timber volumes equal to the present volumes (column 1) in that great Lake-Central-South belt would be adequate to maintain about one third of the 1925–29 saw-timber drain. This disparity would be further increased with the smaller growing stocks under the other two assumptions.

The sustained-yield possibilities indicated for the western regions have little significance because of the abnormally large volumes of over-mature timber now present. It is obvious that the true sustained-yield possibility of the western regions is less than that indicated in the first column and perhaps even less than that indicated by the calculated 1950 growing stocks (column 3). Although it is believed that a great many years will elapse before all of the more remote and otherwise less desirable stands become economically available, it is probable that as time passes, the margin of accessibility will be extended.

These calculations, as previously implied, are useful in giving a proper perspective to the existing growing stock situation from the standpoint of sustained yield. As a matter of fact, the situation is somewhat less favorable than might be implied from the figures alone. Individual properties or localities within regions are, as a rule, not characterized by the regular distribution of age classes needed for sustained yield in keeping with actual stand volumes. Such distribution of age classes may not exist even for the region as a whole. Moreover, heavy depletion is actually taking place quite generally in the cordwood and second-growth saw-timber stands below rotation age.

It remains to consider sustained yields which might be obtained under some combination of intensive forestry, extensive forestry, and simple protection against fire. It is believed that the play of economic forces will lead to the practice of intensive forestry on the most favorable situations before anything more than fire protection will be economically justifiable upon the poorer and more remote lands. At the same time, because of ownership or other factors, certain lands will be given little, if any, forestry treatment even though physically and economically suited to it. Some combination of extensive and intensive forestry, however, appears to be closer to the probable realities than would a premise which involved only extensive forestry or only intensive forestry. The relative acreages assumed for each type are in no sense forecasts of what will happen.

For this discussion simple protection means a degree of protection which will prevent fires from causing a serious drain at any time.

Extensive forestry embraces fire protection as just defined, and such cutting practices or simple silvicultural measures as are necessary to maintain production in sufficient quantity for commercial utilization. It would include, as occasion requires, such measures as deferring cutting until reproduction has become established, slash disposal as an aid in fire protection, the preservation of advance reproduction, the leaving of seed trees, prevention of overgrazing, and girdling cull hardwoods to permit valuable young growth to develop. It will not ordinarily include planting.

Intensive forestry is used to include a very high degree of protection against fire, insects, and disease. In addition, it will require cutting practices and various cultural measures, including planting, to increase both the quantity and quality of the yield to a point consistent with the productive capacity of the land. All of the areas under intensive forestry, therefore, would be in a good growing condition and well stocked with desirable species.

An allocation of forest areas according to the intensity of management which might theoretically be attained at some time in the distant future is illustrated by table 22. The application of intensive and extensive forestry on anything like the scale indicated in this table can, of course, be brought about only after a long period, perhaps a tree generation, and then only as a result of the most aggressive and sustained efforts of all agencies concerned. This table takes cognizance not only of the present commercial forest areas, but also of the 54.7 million acres of farm land which are estimated to be available for forest use because not needed for agriculture. (See section, "Forest Land the Basic Resource.") The table classes as productive forest land not only the open or denuded areas which may be expected to restock naturally during a long period of years, but also the area which is set up for planting under the section "Reforestation of Barren and Unproductive Land." It excludes as not available for timber use those areas which other sections of this report estimate will need to be reserved for recreation or other purposes. Under the general application of forestry practices assumed in this calculation denudation would be largely eliminated. Whatever error may be involved because of denudation before this theoretical plan of land use could be attained is on the optimistic side. Therefore, recommendations for action based on the resulting growth calculation will be conservative.

The theoretical yield which might be obtained under the conditions set up in table 22 is shown in table 23. The calculations are shown only on a cubic-foot basis, but the bulk of the cut would, of course, be in trees of saw-timber size.

TABLE 22.—*Hypothetical allocation by types of management of areas prospectively available for timber use*

Region	Total[1]	Area for intensive forestry	Area for extensive forestry	Area for simple protection		
				Forested land		Not likely to restock[2]
				Relatively favorable	Relatively unfavorable	
	Million acres	*Million acres*	*Million acres*	*Million acres*	*Million acres*	*Million acres*
New England	23.1	5.0	12.0	1.8	0.7	3.6
Middle Atlantic	30.1	6.0	14.0	2.1	--- -----	8.0
Total	53.2	11.0	26.0	3.9	.7	11.6
Lake States	60.7	11.0	30.2	5.0	5.0	9.5
Central	75.6	10.0	41.8	5.9	8.6	9.3
South	205.9	30.0	131.5	14.8	17.8	11.8
Total	342.2	51.0	203.5	25.7	31.4	30.6
Pacific Coast	57.4	7.0	33.0	4.8	8.8	3.8
North Rocky Mountain	26.8	.5	10.0	4.1	10.4	1.8
South Rocky Mountain	29.0	.5	6.4	2.2	18.4	1.5
Total	113.2	8.0	49.4	11.1	37.6	7.1
All regions	508.6	70.0	278.9	40.7	69.7	49.3

[1] Includes the 494.9 million acres of present commercial forest area and the 54.7 million acres of farm land now available for forestry, with reductions of 2 million acres of forest land to be cleared for agriculture in the West and of 39 million acres for recreation and other purposes.

[2] Residual area of denuded commercial forest land and agricultural land available for timber use, after allowing natural restocking of 42.8 million acres and planting of 25.5 million acres.

TABLE 23.—*Theoretical future growth under the hypothetical allocation of areas to types of management given in table 22*

Region	Total theoretical growth	Intensive forestry area	Extensive forestry area	On simple-protection areas	
				Relatively favorable for forestry	Relatively unfavorable for forestry
	Million cubic feet	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*
New England	747.9	307.0	398.4	35.5	7.0
Middle Atlantic	1,001.8	366.6	575.4	59.8	
Total	1,749.7	673.6	973.8	95.3	7.0
Lake	1,773.4	590.7	1,081.2	76.5	25.0
Central	1,959.1	483.0	1,295.8	111.5	68.8
South	9,500.0	2,193.0	6,759.1	423.3	124.6
Total	13,232.5	3,266.7	9,136.1	611.3	218.4
Pacific Coast	2,059.2	686.1	1,230.9	54.2	88.0
North Rocky Mountain	499.1	30.5	308.0	56.6	104.0
South Rocky Mountain	214.5	11.9	95.4	15.2	92.0
Total	2,772.8	728.5	1,634.3	126.0	284.0
All regions	17,755.0	4,668.8	11,744.2	832.6	509.4

The growth rates used in this calculation were derived from detailed consideration of present growth and future yield capacities for the principal timber types in each region. The areas relatively unfavorable for forestry as a rule are characterized by poor growing conditions. Nevertheless, in recognition of the fact that some may become a factor in timber supply, a nominal growth rate was applied. The present average growth of 21 cubic feet per acre for the 432 million acres of present commercial forest land now in productive condition was applied to those relatively favorable areas allocated to simple protection. In the areas allocated to extensive forestry the growth rate averages about 42 cubic feet per acre, while on the intensive forestry area the average rate for all regions is about 67 cubic feet.

The estimated future annual growth for the entire 508.6 million acres, on the basis of the assumed allocations to the several types of management is 17,755 million cubic feet. The distribution of this growth, in comparison to present growth, is shown in figure 19. The saw timber equivalent of this total growth is estimated to be about 60 billion board feet.

Among the requisites for attaining and maintaining such a yield is the establishment of forest growing stock adequate in character and amount. The minimum growing stocks which would be required to sustain a yield equal to the growth shown in table 23 on a saw-timber basis, with uniform rotations as assumed in table 21, is presented in table 24. As a matter of interest there is also included in table 24 the total volume of the existing stands.

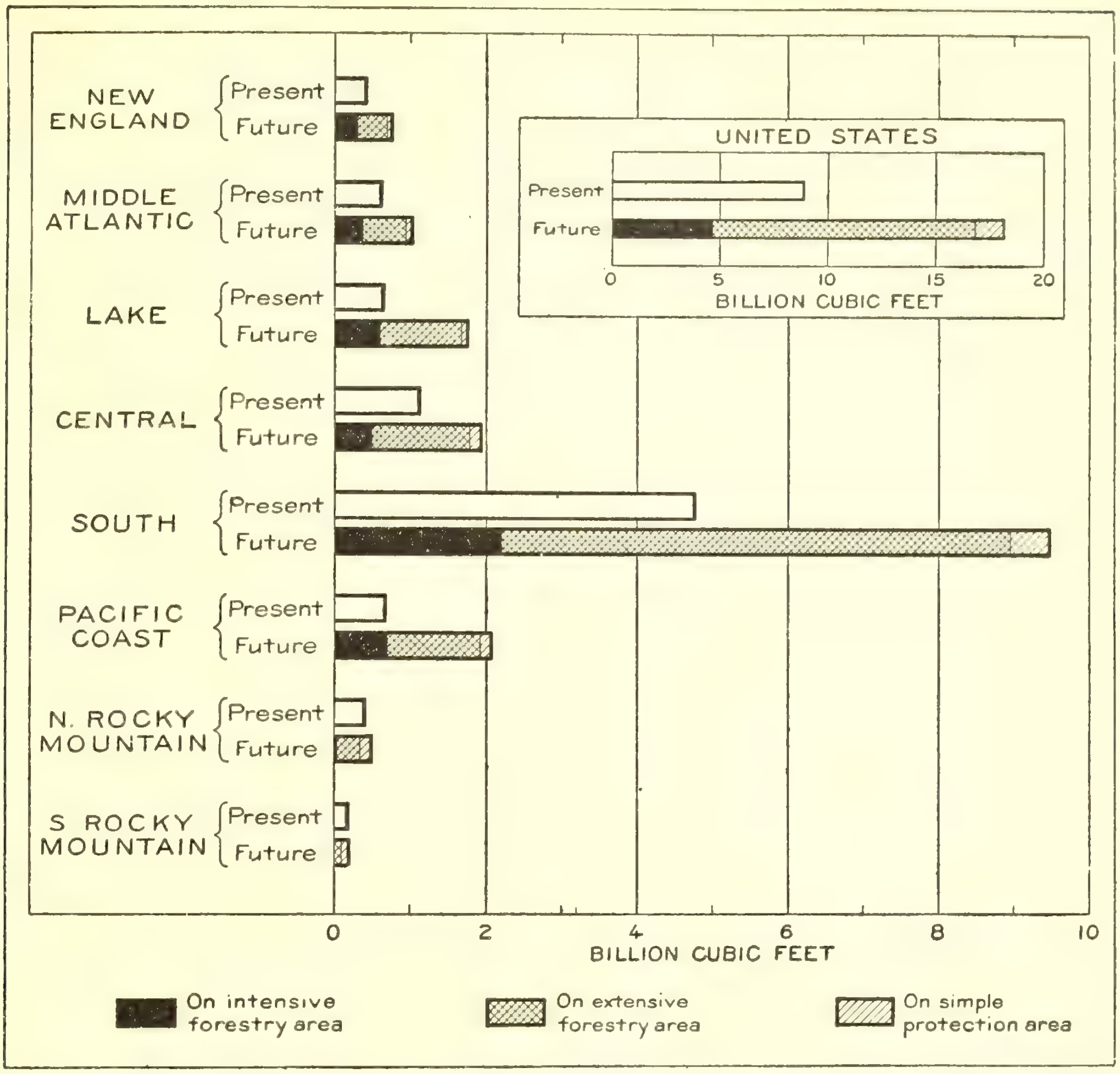

FIGURE 19.—Theoretical future annual growth compared to present growth. (Total growth of saw-timber and cordwood in cubic feet.)

TABLE 24.—*Minimum growing stocks required to maintain theoretical growth shown in table 23*

Region	Total theoretical growth	Growing stocks required	Present growing stocks	Ratio of present to required growing stocks
	Million cubic feet	*Billion cubic feet*	*Billion cubic feet*	
New England	747.9	28.0	25.2	0.9
Middle Atlantic	1,001.8	37.6	22.7	.6
Total	1,749.7	65.6	47.9	.7
Lake	1,773.4	66.6	21.6	.3
Central	1,959.1	73.5	30.7	.4
South	9,500.0	288.0	113.8	.4
Total	13,232.5	428.1	166.1	.4
Pacific Coast	2,059.2	98.8	191.7	1.9
North Rocky Mountain	499.1	29.1	47.8	1.6
South Rocky Mountain	214.5	12.5	33.3	2.7
Total	2,772.8	140.4	272.8	1.9
All regions	17,755.0	634.1	486.8	.8

It would appear that the present volume of timber in New England, if it should all prove to be economically available and were properly distributed as to age classes, would almost sustain the growth indicated in both tables 23 and 24. In the Middle Atlantic region, under the same assumptions, the present stands would have to be increased about 65 percent. In the combined Lake, Central, and Southern regions more than 2.5 times the present growing stock would be needed to achieve the indicated sustained production.

In reality the stands in the East, generally speaking, are not regularly distributed as to age classes. Few of them are in a satisfactory silvicultural condition, and it is doubtful whether all of them will ever become economically available. For these reasons the deficiencies in the growing stocks indicated for the eastern regions probably understate the seriousness of the situation. In short, after allowing for sizable inaccuracies in stand and growth estimates it seems conclusive that the existing growing stocks in the East are much less than adequate to maintain, on a saw-timber rotation, anything approaching the sustained yields set up in table 23. This would be true even if the growing stocks were properly regulated.

In the West, on the other hand, the present stands appear to exceed by more than 90 percent the volume of regulated growing stock necessary to maintain the sustained yield indicated in table 23. However, the factor of inaccessibility, even though it may prove of diminishing importance, will tend to reduce the apparent surplus. Nevertheless, regulated growing stocks in those regions equal to or somewhat less than the present stands would probably be adequate.

SUMMARY

The preceding pages have presented the outstanding aspects of the forest situation in the several regions, both from the standpoint of current growth, and from that of the theoretical sustained-yield possibilities in relation to the existing growing stocks. Without assuming that the calculations involved represent precise accuracy, or that they approximate the rates of drain and growth which will actually take place and which will be governed by circumstances which cannot accurately be foretold, it may yet be concluded that, irrespective of the existing economic depression, a considerable decline in the national cut is inevitable. This decline will be largely, if not entirely, in the eastern regions. The situation in the East is so serious that the severe reduction in the drain on the forest resulting from the economic depression during the past three years may be providential from the standpoint of the welfare of the forest resources.

The severity and duration of this decline in cut, and its ill effects nationally, regionally, and locally may be minimized in a number of ways. Further restricting abnormal losses by fire and other causes will serve to reduce the rate of depletion of the growing stock and facilitate the restocking of cut-over areas. The area of producing forest land can be increased by an aggressive program for planting the large area of open and nonproductive land now available for forestry.

Better utilization methods, more efficient marketing, and the accompanying reductions in waste would make it possible to cut a given quantity of usable products from a smaller volume of timber. Obtaining products other than lumber just as far as practical from improvement or salvage cuttings, using defective trees or portions of the stand which now go to waste incident to saw-timber production would help build up the growing stock. The yield of usable growth could also be increased by careful selection of the stands to be cut and of the trees to be cut within those stands where partial cutting methods can be applied. Those stands and trees should be cut which offer no prospect of making a good rate of growth in volume or value, and those should be left which promise to increase rapidly in volume or value in the comparatively near future. Wherever silvicultural and economic conditions permit, a good stand of thrifty young and middle-aged trees should be left on cut-over lands. Through various silvicultural operations it would be possible to increase the proportion of fast growing or otherwise desirable species and more nearly to maintain that density of stand which is most favorable to rapid growth of usable timber.

While the application of these measures involves many silvicultural and economic factors concerning which much remains to be known, present knowledge is adequate for progressive improvements. Further knowledge can be gained only through a long-time program of research in silviculture, forest products utilization, forest economics, and related fields such as entomology, pathology, and plant and animal ecology.

THE BALANCE BETWEEN TIMBER SUPPLIES AND REQUIREMENTS

Several important factors, some of which are discussed in detail elsewhere in this report, should be briefly reviewed as a basis for an understanding of the relation of our timber supplies to our requirements, and for considering the need or justification for a program of forestry measures to increase supplies.

SHOULD SAW TIMBER BE THE MAJOR OBJECT OF A NATIONAL PROGRAM OF FORESTRY?

Lumber has always been, by all odds, our most important timber product. It accounts for more than half of the total cut. Most other important products may be obtained advantageously, wholly or partly, from trees of saw-timber size. Altogether more than three fourths of the products taken from the forest are obtained from saw timber.

Important though the growing number of chemical and synthetic wood products have been and will continue to be, it is not believed that the prospects for the development of new uses of wood justify the assumption that lumber and other mechanical products of saw timber will cease to constitute the major normal requirement.

Stumpage values for timber to be converted into lumber have in general been higher than for timber to be converted into other products. Furthermore, such other products as veneers and piling which return higher values to stumpage have, for the most part, been cut from trees of saw-timber size.

There are, of course, exceptions as in the case of pulpwood, but in most localities the management of forests for saw timber as the major object offers greater financial advantage than for smaller trees. Moreover, studies made in a number of widely different forest types summarized in table 4 of the section "Status and Opportunities of Private

Forestry" show conclusively that the financial return from the cutting of large saw-timber trees is greater than that from small saw-timber trees, because the products of the former are of higher value, and because the larger trees can be logged and milled much more cheaply than the smaller ones.

In the management of forests for saw timber there will always be a large volume of by-product material which may be converted into pulpwood, fuel wood, posts, or other so-called minor products. This material is available alike from cultural operations, from salvage of trees which may die or be killed by destructive agencies, or from waste incident to removal of saw logs. Not only, in most instances and in most localities, can minor products be thus obtained to the best financial advantage but such use facilitates these cultural and salvage operations which in themselves are a highly desirable feature of intensive and profitable forestry. These points also are further elaborated in the section on "Status and Opportunities of Private Forestry."

In short, it seems altogether probable that the best results in management, all things considered, will be achieved and that the normal requirements of the country for forest products best be met if regional and national programs of forestry are based upon saw timber as the major object of management and if sufficiently long rotations are used to produce saw timber of considerable size and relatively high quality.

PRESENT AND PROSPECTIVE NORMAL TIMBER REQUIREMENTS

The term "timber requirements" is used to denote the measure of use by consumers who are afforded a reasonable latitude in choice of readily available materials including timber and timber products. "Normal" requirements refers to the volume of such use that might logically be expected when general economic conditions are such that the Nation is conscious neither of depression nor of unusual prosperity.

The most tangible available criterion of requirements is consumption. However, since consumption of timber is likely to vary with the abundance, suitability, and cheapness of the supply, it affords only an approximate measure of requirements; it is likely to be less than requirements when ample suitable supplies are not readily available.

The impossibility of measuring accurately the net future effect of a complex of many influencing factors renders it impractical to make a precise forecast of future requirements. However, the section "Our National Timber Requirements", which follows, discusses in some detail the influence of various factors upon recent and prospective trends for the more important classes of timber commodities. That discussion indicates that 31 to 34 billion board feet is a fair measure of present normal requirements for lumber. It is not unlikely that research and improved manufacturing and marketing practices may, in the future, expand this normal requirement. On the other hand, in some regions and with respect to special commodities there is, for many years at least, the prospect of limited supplies. All things considered it appears reasonable to include a figure of 32 billion board feet of lumber in our estimate of normal timber requirements. This is appreciably below the consumption prior to the current economic depression.

The consumption of fuel wood, quantitatively the most important commodity next to lumber, has undoubtedly declined considerably during the past 20 years. However, it seems likely to continue as the chief fuel in rural sections. Present consumption may now approximate a minimum. It is estimated in the discussion of production (see table 13) that, of the total production of 61 million cords, 42 million cords, or over 4 billion cubic feet, should be considered as representing the actual drain for fuel wood. There is no clear justification for changing that figure for purposes of the present consideration.

Paper and other wood-pulp products appear to offer the prospect of a greater proportionate increase in timber requirements than does any other important class of timber products. At present our own forests supply only 44 percent of the pulpwood represented in our manufacture and consumption of paper and other wood-pulp products. The remainder is imported in the form of pulpwood, pulp, or paper. It is variously estimated that, translated into terms of pulpwood, the total requirements for wood-pulp products may by 1950 reach a figure between 22 and 30 million cords. For present purposes we may use a figure of 25 million cords. There is strong justification for becoming nationally self-sufficient in pulpwood supplies. The reasons are elaborated in the discussion on pulpwood, pulp, and paper in the section "Our National Timber Requirements". We may estimate that 25 million cords of pulpwood would mean about 2,758 million cubic feet, of which about 135 million cubic feet can possibly be considered as coming from Alaska. This would leave some 2,623 million cubic feet to be supplied by the forests of the United States proper.

Trends in minor and miscellaneous timber products tend to offset each other to such an extent that no other changes in the timber-use portion of the drain table for the period 1925–29 appear justifiable for purposes of the present discussion.

Although it is not considered likely that abnormal losses through fire and other causes will ever be eliminated, it seems logical to assume that a national program of forestry would justify reducing the loss from fire to one half and from other causes to three fourths of the 1925–29 estimates.

This basis of possible requirements and losses translated into terms of forest drain for use in considering the future situation as to normal timber requirements is briefly summarized as follows:

Type of drain	Saw timber (million board feet)	All timber (million cubic feet)
Lumber	32, 000	6, 207
Fuel wood	7, 047	4, 003
Pulpwood	4, 363	2, 623
Miscellaneous products	8, 121	2, 533
Fire losses	695	435
Other losses	2, 552	739
	54, 778	16, 540

REGIONAL INTERDEPENDENCE FOR TIMBER SUPPLIES

The extent to which some important consuming regions depend for their timber supplies upon other regions is not always fully appreciated. Figure 20 illustrates this relationship between production and consumption for lumber and other products of saw timber. It will be observed that the South and the Pacific Northwest are the two outstanding producing regions. Both produce far more than they consume. On the other hand, consumption in the other eastern regions exceeds production by a very wide margin. This is most notably so in the Middle Atlantic region.

In the earlier discussion on growth, it was pointed out that it does not appear feasible to sustain permanently the 1925–29 rate of drain, and even less to increase it in the four importing regions of the East. It is also shown that in the South, a considerable curtailment in the 1925–29 rate of drain appears to be inevitable in the not far distant future even in the absence of an economic depression. The North and South Rocky Mountain regions, though important locally, do not cut any great figure in the national situation as to timber supplies. If requirements are to continue on the basis outlined, the assurance of ample supplies for all regions during the next few decades appears to hinge largely upon the question of how far the Pacific Coast region

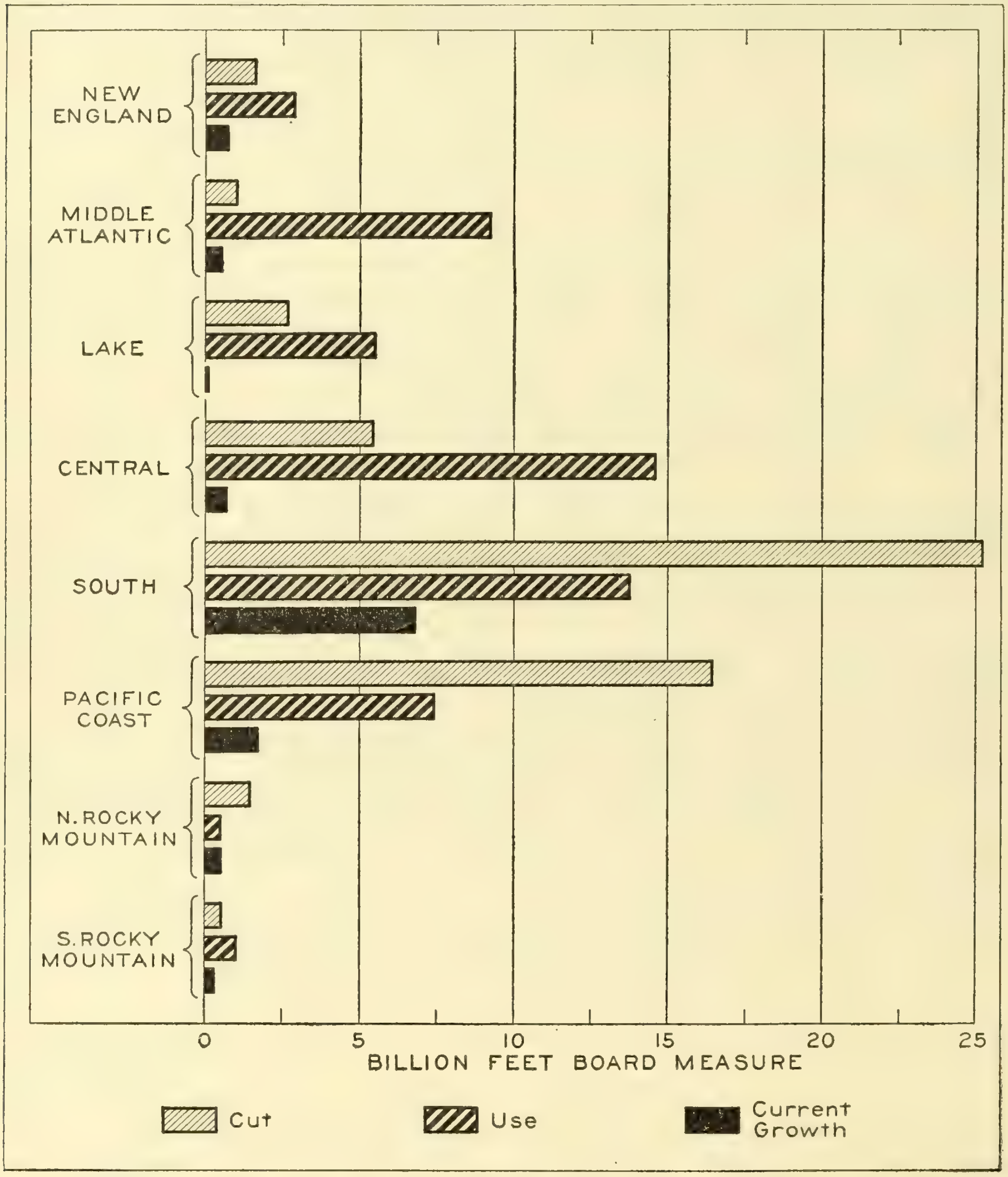

FIGURE 20.—Annual saw-timber cut, use, and current growth contrasted, by regions.

can go in making up the deficits in production in the four eastern regions as the exports to other regions from the South fall off. To say the least, it appears to present a very serious problem. It strongly suggests, from the long-range standpoint, the wisdom of far-reaching constructive measures for expanding supplies.

The corresponding relationships for all timber consumption and production, as measured in cubic feet, are shown in figure 21. The contrasts, though not so striking, because of the larger degree of regional independence so far as fuel wood and other minor products are concerned, is still just as significant in principle.

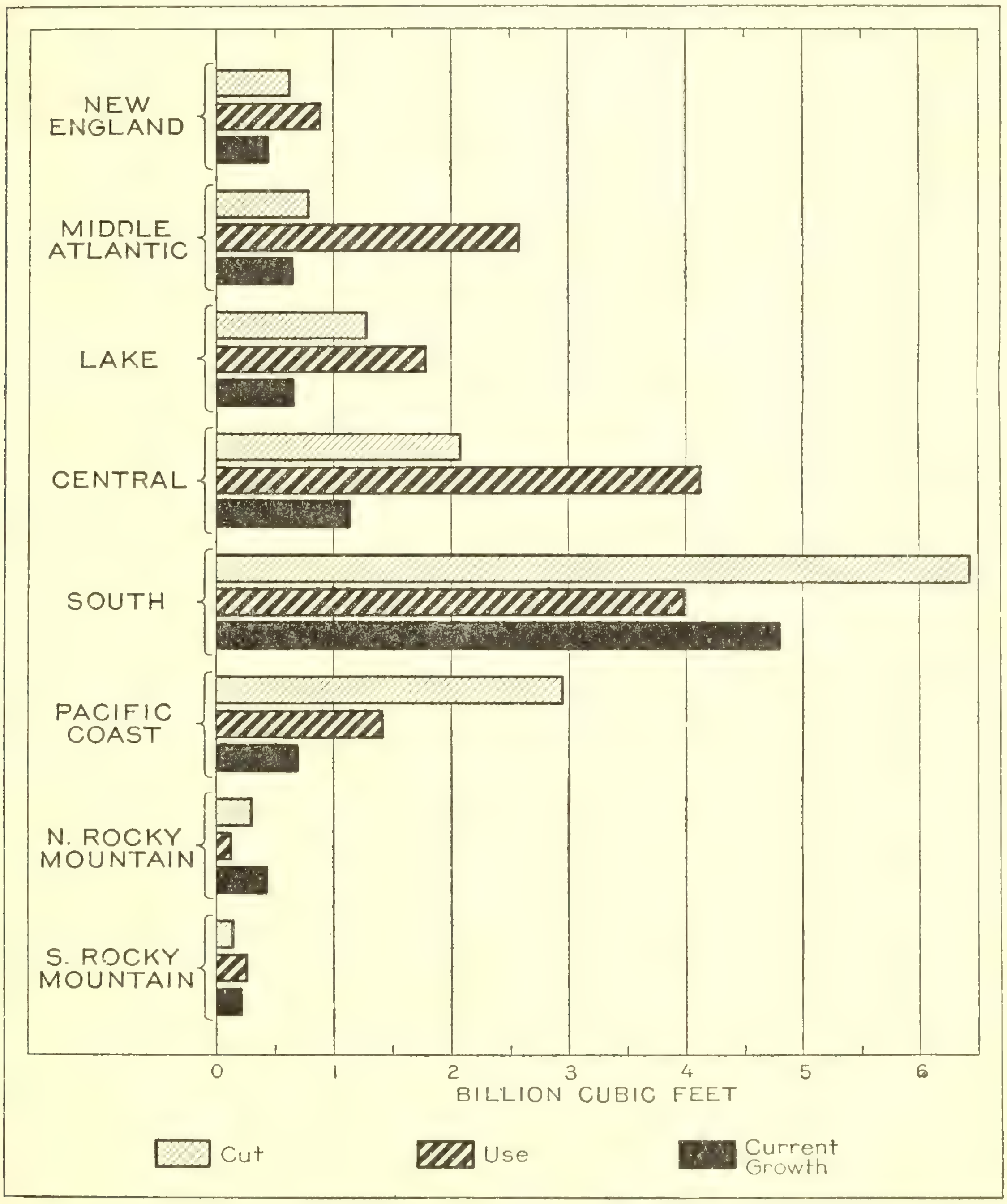

FIGURE 21.—Total annual timber cut, use, and current growth contrasted, by regions.

It is worth mention that the existing degree of interregional dependence is the reason for a volume of commerce which is of considerable importance to the railroads and other transportation agencies. Figures 20 and 21 also show the growth for the several regions in relation to production and consumption. The significance of these growth relationships is brought out in the preceding discussion under growth.

RELATION OF FOREIGN SUPPLIES AND MARKETS

Up to 1914 the trend of timber consumption was gradually upward in most of the important timber-consuming countries outside of the United States. (See following section, "Trends in World Wood Consumption".) Requirements for fuel wood tended to decrease, requirements for saw timber, and especially for pulpwood, to increase. When normal activities were resumed after the World War, the same tendencies continued until the beginning of the general economic depression in 1929. Russia, the largest consuming country except the United States and at the same time the possessor of the greatest forest resource, had not yet reached the pre-war consumption level, but her output of timber has been increasing rapidly and her plans call for a large increase in consumption during the next few years, as industrialization proceeds. Outside of Europe and North America, very few countries are yet industralized, but the trend is in that direction in many of them. Industrialization has always been accompanied by an increase in timber consumption—particularly of timber for construction, secondary manufacture, and pulp. Softwoods are preferred to hardwoods for a majority of uses. This preference seems likely to continue if softwoods are available.

The world's softwood supplies are being depleted. The importing countries and most of the exporting countries of Europe can increase their production very little or not at all, because they are now cutting up to the growth capacity of their forests. The only possible important sources of export supply are Russia, Canada, and the United States. The depletion of Canadian forests has already gone so far that no great increase in exports can be looked for. Russian forests have also been seriously depleted during recent years, and the quantity of timber economically available is believed to be insufficient to meet Russia's own requirements if the country develops according to plan.

It is doubtful whether Russian timber exports will maintain permanently a level as high as her pre-war exports. If supplies from Russia are cut off or reduced, as seems likely to happen within a few years, importing countries will have to turn to other sources. The southern pine and Douglas fir regions of the United States are the logical places to obtain these supplies. They are strategically located with respect to water transportation, and they can grow softwood timber faster than almost any other large region in the world.

About one fourth of our timber consumption is hardwood. Tropical hardwoods, particularly for special purposes, are now contributing to a degree to this requirement, and they may be more of a factor in the future. To place great reliance upon this source of supply would, however, be to overlook certain definite obstacles. The tropical forests in many regions have been depleted by centuries of misuse, burning, and cutting, so that present stands are composed mostly of comparatively worthless trees. The extensive areas of relatively good stands are characteristically composed of many species, only a few of which have as yet become merchantable. Much study will be required to determine the properties and uses, as well as suitable methods of manufacture, for many of the most plentiful species.

In brief, the indications are strongly that the United States can rely permanently upon foreign sources in no important degree for timber supplies. Beyond this there exists a situation of world consumption of softwood in excess of growth. This cannot continue indefinitely and still permit the world's increasing softwood requirements to be met. Some students of the situation believe that world markets for softwoods will be such that they could consume several billion cubic feet of United States softwood supplies annually if cheaply and abundantly available. The significance of this is that our requirements for domestic consumption should not be the sole measure of the markets for United States forest products. The possibility of greatly increased exports should enter into the consideration of a program of constructive use of the Nation's forest lands.

A PLAN OF FOREST LAND MANAGEMENT CONSISTENT WITH NORMAL REQUIREMENTS FOR TIMBER

It has been estimated (see section "Forest Land the Basic Resource") that after allowing for withdrawals of forest land mainly for recreation, there is available for permanent timber use some 508.6 million acres of land. This includes commercial forest land and open land not needed for agriculture but which, so far as soil and other natural conditions are concerned, would be suited to timber growing.

How much of this available land, if it were under management for timber production, would afford a sustained yield on saw-timber rotations consistent with normal requirements? This will depend, of course, upon the type, or rather, types of management imposed. It does not seem economically practical to assume that a unified, blanket intensity of management could be spread over all of the land available for timber use. A combination of intensive forestry, extensive forestry, and simple protection, as defined in the preceding discussion of Timber Growth, is believed to be more logical. Such a combination affords a wide range in estimated sustained yield through the possibility of varying the acreages allotted to the several types of management.

Three examples of theoretical combinations of management will illustrate the wide range of results that may be obtained. (Table 25.) The first is referred to for convenience as plan I. This, although believed to represent a situation somewhat more favorable than that which now exists, may be thought of as involving the minimum in the way of a national program of forestry. It is what might possibly result from putting forest fire protection on a satisfactory basis, making a large curtailment in the overcutting in the eastern regions, and expanding somewhat the areas now under intensive and extensive forestry. It appears that this plan would develop a sustained yield of between 10.5 and 11 billion cubic feet. This is 20 to 25 percent more than the estimated present current growth, but far less than either the 1925-29 drain rate or our estimate of normal reqirements.

TABLE 25.—*Comparative plans for intensity of management of available forest land*

Management unit	Area	Growth rate	Total annual yield
	Acres	*Cubic feet per acre*	*Cubic feet*
PLAN I			
Intensive forestry	10, 000, 000	66. 7	670, 000, 000
Extensive forestry	100, 000, 000	42. 1	4, 210, 000, 000
Protected relatively favorable for forestry	254, 100, 000	20. 6	5, 230, 000, 000
Protected relatively unfavorable for forestry	69, 700, 000	7. 3	510, 000, 000
Open	74, 800, 000		
Total	508, 600, 000		10, 620, 000, 000
PLAN II			
Intensive forestry	100, 000, 000	66. 7	6, 670, 000, 000
Extensive forestry	338, 900, 000	42. 1	14, 270, 000, 000
Protected relatively unfavorable for forestry	69, 700, 000	7. 3	510, 000, 000
Total	508, 600, 000		21, 450, 000, 000
PLAN III			
Intensive forestry	70, 000, 000	66. 7	4, 670, 000, 000
Extensive forestry	278, 900, 000	42. 1	11, 740, 000, 000
Protected relatively favorable for forestry	40, 700, 000	20. 6	840, 000, 000
Protected relatively unfavorable for forestry	69, 700, 000	7. 3	510, 000, 000
Open	49, 300, 000		
Total	508, 600, 000		17, 760, 000, 000

Plan II envisions an extremely far-reaching application of intensive and extensive forestry. It may be considered as an ideal which would use for forestry all of the land estimated to be now available for that use, and would also leave a comfortable margin for a large ultimate increase in export trade or for other reasons above our estimate of normal timber requirements. It would also afford the maximum in the way of protection benefits and other nontimber uses.

Plans I and II, at opposite extremes, will serve in some measure to give a perspective to the timber-producing potentialities of our available forest lands. Any student of the forest situation may interpolate within this broad range such combination of areas allotted to different types of management as he may deem consistent with timber requirements, with the advantages of using for forestry all of the land now available for it, and with other factors.

Plan III, which is the combination presented in detail in tables 22 and 23, is offered as a working basis for the formulation of a Nation-wide program of forest-land use and forestry action consistent with our estimate of normal timber requirements. Timber requirements, rather than the use for forestry of all land available for it, is made the controlling consideration. It does, however, visualize a very great advance over the present situation, not only as to the amount of sustained timber yield assured, but also in the acreage of land devoted to forestry. It would mean, for example, the planting of some 25 million acres of land, or 13 times the amount estimated to have been planted by all agencies up to this time. If fully effected, say, by the close of the century, it would involve an annual increase of about a million acres in area under intensive forestry. It would mean a very great expansion of the area under extensive forestry. It would include what might be termed satisfactory fire protection on the total area in table 25, and a reduction in losses from disease, insects, etc.

It is believed that, from the standpoint of timber requirements, a sustained annual yield of 17¾ billion cubic feet, such as this plan for forest land use contemplates, is a sound, conservative objective for the following reasons:

(1) Our estimate of normal requirements is 16.5 billion cubic feet. A national program of forestry should be based upon a sustained yield of at least a billion cubic feet more than this as a margin for safety.

(2) Beyond the estimated normal requirement of 16.5 billion cubic feet is the ultimate probability that the United States may supply the world softwood markets on a much larger scale than hitherto.

(3) Such a far-reaching and drastic program as that embodied in this tentative set-up can hardly be expected to be brought to the point of complete accomplishment. For example, short of sweeping public regulation of privately owned forest lands and a large program of further public acquisition, there is no means of insuring the practice of forestry on anything like the acreage of forest lands involved in this plan.

A very long time will be required, probably 60 to 80 years at least, before anything approaching full accomplishment under plan II or plan III can be realized. Moreover, the realization of such a plan involves several major features, probably not all of which can be carried forward at once with full speed. It is, therefore, fitting to inquire what single feature deserves first consideration as measured by its effect upon bringing sustained timber yield into balance with requirements as promptly as possible.

The most unsatisfactory aspect of our present forest situation, from the standpoint of timber use, is believed to be the tremendous impoverishment of the growing stocks in the eastern regions. It is one that has in the past had relatively little general recognition. By and large, cutting has been at the expense of capital account. A situation has been reached in these eastern regions where, according to the estimates presented under the heading Sustained Yield Possibilities in the preceding discussion of Timber Growth, regulated growing stocks equivalent to the volume of present stands would support, under saw timber rotations, a sustained yield equal only to about two fifths of that which is called for by plan III.

Generally speaking, a forest property upon which stands are already established, even though inadequately, can be developed into a regulated sustained yield enterprise at less expense and more quickly than one upon which established stands are largely lacking. The relative importance of taking every advantage of the existing stands in the East as the main basis for attaining a satisfactory growing stock situation is, therefore, obvious.

In the opinion of the authors the safeguarding of existing stands in the East and their development into adequate growing stock is the most urgently needed constructive measure. This fact does not, however, minimize the necessity of providing for an adequate planting program for areas not likely to restock naturally, for the development of adequate protection against fire, insects and disease, and for the control of cutting in the western regions, to facilitate the conversion of those forests to an adequate sustained yield basis. All of these features are essential elements in the realization of either plan II or plan III.

Recent trends in growth and drain on our forest resources, if continued, will further aggravate an already very unsatisfactory condition. Although we appear to have a potential forest land resource, extensive enough to meet the nation's forest requirements, it will be necessary, in order to meet such requirements, to effect a very great extension in the practice of forestry and in measures to build up the forest growing stock, and to protect and maintain this growing stock on a sustained yield basis. In addition to the desirability of assuring adequately that the requirements of the United States for timber products and other forest uses and services will be met, we have the economic incentive for making constructive use of a huge area of forest land which by and large is not susceptible of any other major commercial use.

OUR NATIONAL TIMBER REQUIREMENTS

By Frank J. Hallauer, Principal Engineer

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INTRODUCTION

The purpose of this analysis is to review past experience and to evaluate current trends in the consumption of wood and other important forest products in the United States, in order to throw as much light as possible on what the Nation's normal needs for such products, translated into terms of timber, may be in the future. The study therefore has to do only with effective demand for forest products as commodities of consumption, leaving to other discussions the needs of the Nation for forests for such purposes as regulation of stream flow, control of erosion, recreation, and fostering of wild life.

"Requirements" is not a wholly satisfactory term to define the extent of past, present, or future use of wood. Where timber is abundant and easily accessible, "requirements" inevitably absorb a far greater quantity of this cheap and adaptable raw material than would come into demand under other circumstances; competition from other materials is reduced; substitution moves rather in the opposite direction, and wood replaces other more costly and less readily accessible materials. On the other hand, where wood is scarce and hard to get, actual use is not a measure of what requirements might be under more favorable conditions. The community or region may not consciously demand more wood and may yet be at a disadvantage in a number of ways through lack of an abundant supply of wood at hand.

For want of a better term, however, "requirements" is used, not to denote irreducible needs, but as a measure of use by consumers afforded a reasonable latitude in choice of materials.

Consumption, while deficient in certain respects as a gage, is the only practical measure of past and current commodity requirements and is therefore accepted in this analysis with such allowances as judgment dictates. An absolute measure of requirements would necessarily be quite theoretical, and unreliable at best.

Since no one can say precisely what our timber requirements will be at any future time, this report does not attempt to do so. Sound policy making, however, must aim to anticipate requirements with some degree of probability, and this report is an attempt to supply part of the needed data. Unfortunately the record of past experience is none too good, and the present investigation emphasizes the importance of better statistics of requirements and more systematic study of the factors affecting them.

COMMODITIES CLASSIFIED

The report is confined to the more important industrial products and to the use of wood for domestic fuel, omitting products which have only minor influence on the volume of demand. Lumber, which includes material for construction and for boxes, furniture, vehicles, railroad cars, woodenware, toys, and other factory products, represents by far the largest industrial consumption of timber, and is of the greatest present concern. Pulpwood comes next. While far below lumber in importance if gaged by quantity of timber consumed, it is of vast importance when measured by value of products and the part that pulp products play in our civilization. Railroad ties are important both as to quantity of timber consumed and service rendered. In naval stores (turpentine and rosin), the United States is the principal world producer, exporting almost twice as much as all other countries combined. These five classes of forest products—lumber, pulpwood, railroad ties, fuel wood, and naval stores—will be the principal subject of discussion.

The study is carried only through 1929 for most items, partly because data for later years are not complete, but more particularly because the present depression overshadows completely all other factors in commodity consumption since that year. The present low consumption, as a phase of the depression, is a general condition that does not in itself indicate a permanent change for one commodity any more than for another. For instance, the decline of 50 percent in lumber consumption from 1929 to 1931 should not be confused with the normal declining trend which will be shown to have prevailed since 1906. Other manufacturers have experienced abnormal declines since 1929, and there seems no reason for assuming that lumber products will not recover from the effects of the depression in proportion to the recovery of all other commodities.

LUMBER CONSUMPTION TRENDS

STATISTICAL

From 1809 to 1906 the trend of lumber consumption in the United States was constantly upward; since 1906 it has been downward, both per capita and in the aggregate. Consumption for the years 1809 to 1931 is shown in table 1 by balancing production, imports, exports, and changes in stocks. In figure 1 the total and per capita lumber consumption trends since 1899 are shown in relation to the trend for all manufactures and the population curve. Total lumber consumption declined from a maximum of approximately 45 billion board feet in 1906 to 34 billion in 1929. While there may be some question as to whether 1929 was a "normal" year in view of a generally recognized depression in agriculture, the collapse of the stock market, and other adverse factors, yet there is reason to believe, as explained later, that lumber consumption in that year was approximately of the expected normal proportions. The more precipitous drop since 1929 registers the abnormal effect of the current general depression and cannot be interpreted as a change in the long-time trend. Per capita consumption climbed from 460 board feet in 1899 to a maximum of 525 board feet in 1906, and then declined to 275 feet in 1929. The figure reported for 1931 is only 130 board feet.

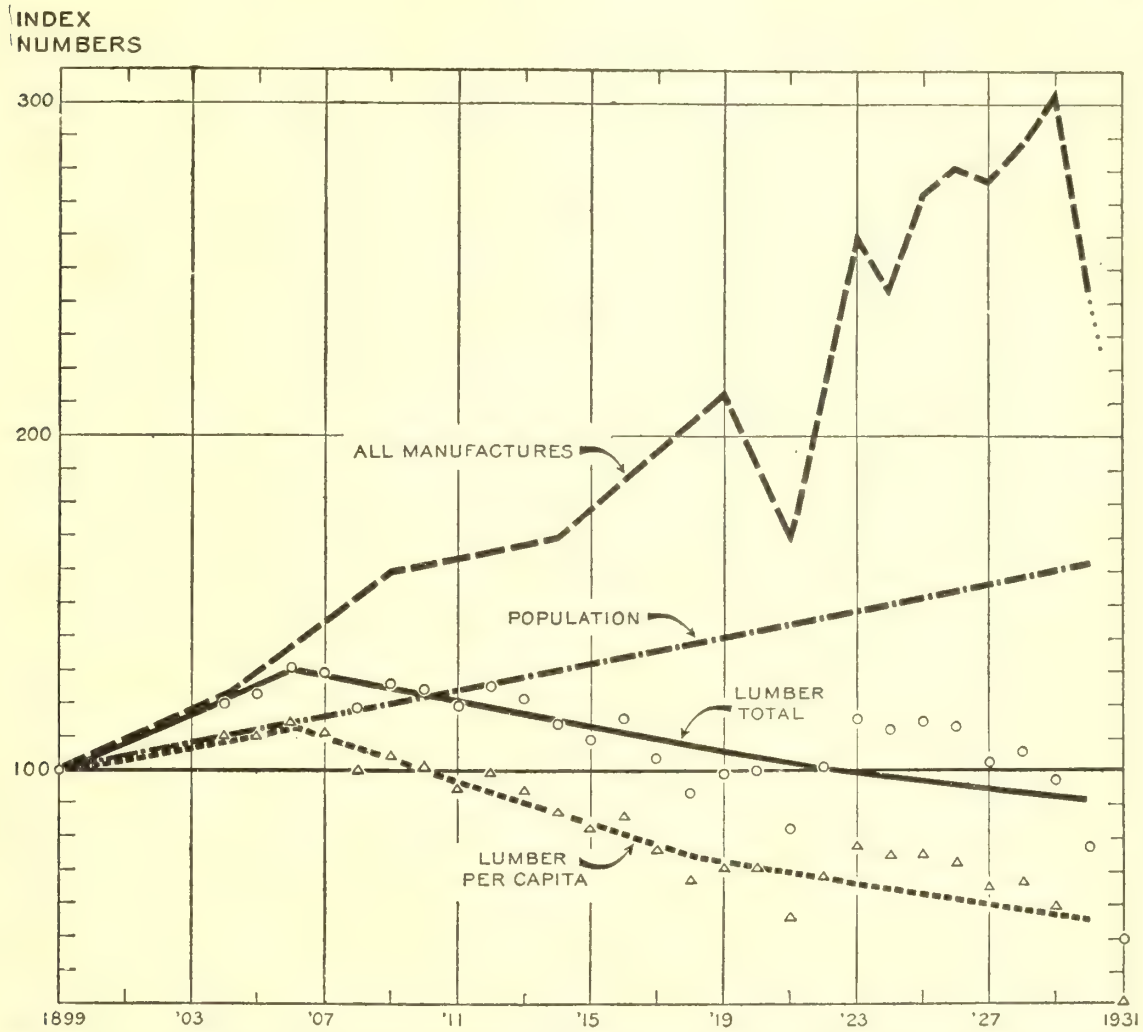

FIGURE 1.—Lumber consumption trends, compared with trends of all manufactures and population.

TABLE 1.—*Lumber production, exports and imports, and consumption, specified years, 1809–1931*

Year	Production			Exports	Imports	Changes in mill stocks	Visible consumption	Per capita consumption (rounded)
	Softwood	Hardwood	Total					
	M ft. b.m.	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*Ft. b.m.*
1809			400, 000				400, 000	55
1819			550, 000				550, 000	55
1829			850, 000				850, 000	65
1839			1, 604, 000				1, 604, 000	95
1849			5, 392, 000				5, 392, 000	235
1859			8, 029, 000				8, 029, 000	260
1869			12, 755, 543	134, 370	332, 692		12, 953, 865	340
1879			18, 091, 356	275, 102	355, 304		18, 171, 558	365
1889			27, 038, 757	571, 075	648, 174		27, 115, 856	435
1899	26, 371, 336	8, 706, 259	35, 077, 595	1, 004, 464	423, 928		34, 497, 059	460
1904	32, 538, 000	10, 462, 000	43, 000, 000	2, 156, 581	746, 556		41, 589, 975	505
1905	32, 960, 000	10, 540, 000	43, 500, 000	2, 012, 049	938, 001		42, 425, 952	505
1906	34, 900, 000	11, 100, 000	46, 000, 000	2, 317, 477	1, 178, 701		44, 861, 224	525
1907	34, 946, 000	11, 054, 000	46, 000, 000	2, 501, 486	1, 056, 965		44, 555, 479	510
1908	31, 945, 000	10, 055, 000	42, 000, 000	2, 064, 748	894, 877		40, 830, 129	460
1909	33, 896, 959	10, 612, 802	44, 509, 761	2, 293, 242	1, 083, 018		43, 299, 537	475

TABLE 1.—*Lumber production, exports and imports, and consumption, specified years, 1809–1931*—Continued

Year	Production			Exports	Imports	Changes in mill stocks	Visible consumption	Per capita consumption (rounded)
	Softwood	Hardwood	Total					
	M ft. b.m.	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*M ft. b.m.*	*Ft. b.m.*
1910	34, 029, 000	10, 471, 000	44, 500, 000	2, 652, 197	1, 117, 504	------------	42, 965, 307	465
1911	33, 020, 000	9, 980, 000	43, 000, 000	3, 009, 434	925, 488	------------	40, 916, 054	435
1912	34, 695, 000	10, 305, 000	45, 000, 000	3, 038, 173	1, 084, 720	------------	43, 046, 547	455
1913	34, 065, 000	9, 935, 000	44, 000, 000	3, 293, 037	1, 031, 016	------------	41, 719, 979	430
1914	31, 481, 000	9, 019, 000	40, 500, 000	2, 294, 475	949, 136	------------	39, 154, 661	400
1915	29, 655, 000	8, 345, 000	38, 000, 000	1, 526, 618	1, 096, 287	------------	37, 569, 669	380
1916	31, 344, 000	8, 656, 000	40, 000, 000	1, 571, 545	1, 265, 561	------------	39, 694, 016	395
1917	28, 325, 000	7, 675, 000	36, 000, 000	1, 346, 519	1, 234, 447	------------	35, 887, 928	350
1918	25, 277, 000	6, 723, 000	32, 000, 000	1, 233, 706	1, 246, 712	------------	32, 013, 006	310
1919	27, 407, 130	7, 144, 946	34, 552, 076	1, 677, 843	1, 190, 845	------------	34, 065, 078	325
1920	27, 610, 000	7, 390, 000	35, 000, 000	1, 916, 166	1, 416, 175	------------	34, 500, 009	325
1921	23, 444, 000	5, 556, 000	29, 000, 000	1, 511, 396	902, 216	------------	28, 390, 820	260
1922	28, 922, 000	6, 328, 000	35, 250. 000	1, 960, 639	1, 563, 211	------------	34, 852, 572	315
1923	33, 220, 000	7, 780, 000	41, 000, 000	2, 472, 352	1, 993, 327	−798, 000	39, 722, 975	355
1924	31, 549, 000	7, 951, 000	39, 500, 000	2, 712, 501	1, 766, 068	+247, 000	38, 800, 562	345
1925	33, 284, 000	7, 716, 000	41, 000, 000	2, 648, 023	1, 875, 101	−774, 000	39, 453, 078	345
1926	32, 078, 000	7, 672, 000	39, 750, 000	2, 870, 145	1, 932, 862	+391, 000	39, 203, 717	335
1927	29, 975, 000	7, 275, 000	37, 250, 000	3, 181, 590	1, 781, 116	−425, 000	35, 424, 526	300
1928	29, 852, 000	6, 898, 000	36, 750, 000	3, 382, 281	1, 493, 448	+1, 718, 000	36, 579, 167	305
1929	29, 813, 345	7, 072, 687	36, 886, 032	3, 364, 470	1, 570, 082	−1, 411, 000	33, 680, 644	275
1930	21, 363, 000	4, 737, 000	26, 100, 000	2, 410, 210	1, 240, 120	+757, 058	25, 686, 968	210
1931	13, 875, 000	2, 675, 000	16, 550, 000	1, 770, 058	758, 454	+658, 692	16, 197, 088	130

Forest Service compilation.

In view of the minor fluctuations evident in figure 1, which fail to represent for any one or two years what may be termed the normal trend, per capita consumption can be expressed perhaps more soundly on the basis of 10-year averages, as follows:

	Feet board measure
1900 to 1909	495
1910 to 1919	395
1920 to 1929	315

Statistics do not show specifically the decline in lumber consumption in each field of use, but some break-down is necessary in an effort to find the reasons for the changes that have occurred. The best figures available for the purpose are given in table 2. The period 1912 to 1928 was chosen because statistical studies had been made of consumption in factory products and in sash, doors, and millwork for those years; the balance of total lumber consumed was assumed to have been used in construction. The years 1912 to 1928 cover in the main the period of declining consumption in which we are interested.

Factory products held practically the same relative position in the 1928 distribution as in that of 1912, and fell off only 8 percent in lumber consumed. The percentage of lumber estimated as going to construction in 1928 (72 percent) was only slightly less than that in 1912, but the actual difference of 5.6 billion feet is striking. When this total is analyzed, it is found that the direct-to-construction item accounts for all but 100 million feet of the loss in all lumber between the two years. The decline in direct-to-construction products might suggest a falling off in building were it not for the gain of 32 percent in sash, doors, and millwork, which can only be explained by an increase in building.

TABLE 2.—*Tentative distribution of national lumber consumption for 1912 and 1928*

Class of use	1912 consumption	Per-cent	1928 consumption	Per-cent	Gain (+) or loss (−)	Per-cent
	Ft.b.m.		*Ft.b.m.*		*Ft.b.m.*	
Factory	11,200,000,000	26	10,300,000,000	28	−900,000,000	−8
Construction:						
Sash, door, and millwork	2,500,000,000	6	3,300,000,000	9	+800,000,000	+32
Direct to construction	29,300,000,000	68	22,900,000,000	63	−6,400,000,000	−22
All lumber	43,000,000,000	100	36,500,000,000	100	−6,500,000,000	−15

As a matter of fact, the period from 1919 to 1929 witnessed a boom in construction. Not only did the building industry reach a peak, but both general industrial output and consumption of general goods were at a maximum. This would suggest that a lumber consumption for 1928, even larger than that of 1912, might have been expected. And if lumber use had merely followed general trends, the year 1928 would have seen a per capita consumption at least equal to that of 1912, and on that basis alone the total consumption would have been 54 billion board feet. But the fact of a 5.6 billion feet decline remains.

FACTORS AFFECTING TRENDS OF LUMBER USE IN CONSTRUCTION

Construction, particularly as regards the use of lumber, can be separated into rural and urban classes. Urban construction can be further divided into two distinct types—residential and nonresidential. Table 3 presents a tentative distribution of lumber consumption in these major fields of construction, as explained in the course of the discussion.

THE PASSING OF AGRICULTURAL EXPANSION

The farm is one of our greatest markets for lumber. The total number of farms in the United States has remained almost stationary in the neighborhood of 6½ million for the past two decades, whereas during the previous two decades the number increased at an average rate of 90 thousand annually.

TABLE 3.—*Tentative distribution of direct-to-construction lumber, 1912 and 1928*

Class of use	1912 consumption		1928 consumption		Gain (+) or loss (−)	
	M. ft. b.m.	*Per-cent*	*M. ft. b.m.*	*Per-cent*	*M. ft. b.m.*	*Per-cent*
Rural construction	15,000	51	5,500	24	−9,500	−63
Urban residential	9,000	31	12,000	52	+3,000	+33
Urban nonresidential	5,300	18	5,400	24	+100	+2
Total	29,300	100	22,900	100	−6,400	−22

In other words, by 1910 agriculture had passed the period of expansion so typical of our earlier history. Prior to 1910, if we assume 50,000 board feet as a reasonable estimate of the lumber required for the average farm fully equipped, there was a prospective market for 4½ billion feet of lumber annually for 90,000 new farms. Inasmuch as the process of equipping a farm usually extends over a number of years, the full loss of this market would not be felt immediately, but should show itself definitely within a decade or two after expansion had ceased.

It is true that since 1910 there has been a pronounced shifting of farm location, as illustrated for an intermediate 5-year period by figure 2. Abandonment in the eastern "general-farm" region has been concomitant with acquisition in the western "grain-farm" region. But although farm expansion from 1910 to 1930 may have offset farm abandonment as to the number of farms, a corresponding offset does not apply when the value of buildings is considered. In the regions of abandonment farm buildings averaged $2,700 to $3,100 in value, but in the regions of expansion they averaged only $700 to $2,200. This difference in value of improvements involves a corresponding difference in building-material requirements, which would make itself felt most acutely in the item of lumber.

AGRICULTURAL DEPRESSION

In addition to the halt in agricultural expansion, and of greater significance in the 1928 rural lumber consumption as estimated in table 3, was the enforced curtailment in normal repairs and replacements on account of the agricultural depression that set in immediately after the World War. Such records as are available indicate that expenditures for building repair and replacement on the farms in 1928 were about half those for 1912, after correcting for price index.

On the pre-war estimate of 2,000 feet per farm as the normal annual lumber requirements for repairs, and new construction, a total of 12¾ billion board feet may be figured as required for the Nation's 6,400,000 farms in 1912. Another 2¾ billion feet annually may be added for rural other than farm construction, making the total rural lumber consumption for 1912 about 15½ billion board feet.[1] If, as explained later, the drop in agricultural expansion reduced this by 4½ billion board feet a year, there would remain a requirement of 11 billion board feet for normal repair and replacement. When again approximately half of this amount is deducted for the loss due to post-war agricultural depression, an estimated rural consumption of only some 5½ billion board feet remains for 1928.

This, it is believed, is a fairly dependable check on the figure of 5½ billion board feet assumed in table 3, and its significance does not rest on the accuracy of the division as between agricultural expansion and depression. Decline in lumber consumption due to slowing up of agricultural expansion may have been less than 4½ billion board feet and the decline due to post-war depression more than 5½ billion board feet, but the conclusion is inescapable that these two conditions are the major factors in declining rural lumber consumption trends since 1912.

COMPETITION OF MATERIALS IN URBAN CONSTRUCTION

RESIDENTIAL

Urban and rural-urban[2] population, increasing at the rate of 2 million inhabitants annually from 1920 to 1928, set up a requirement for some 480,000 new family-dwelling accommodations annually. There was also an accumulated shortage up to 1921 estimated at from 1 million to 1¼ million family accommodations. These requirements, along with the effects of a building boom, resulted in a volume of urban residential construction of some 700,000 family units in 1928. The abnormal volume of such construction from 1922 to 1928 is illustrated in figure 3.

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[1] This is the estimate generally used for rural lumber consumption as of that period, and is the one used in table 3.

[2] Rural-urban is that part of the population, adjacent to urban centers, which is urban in character but outside the city limits.

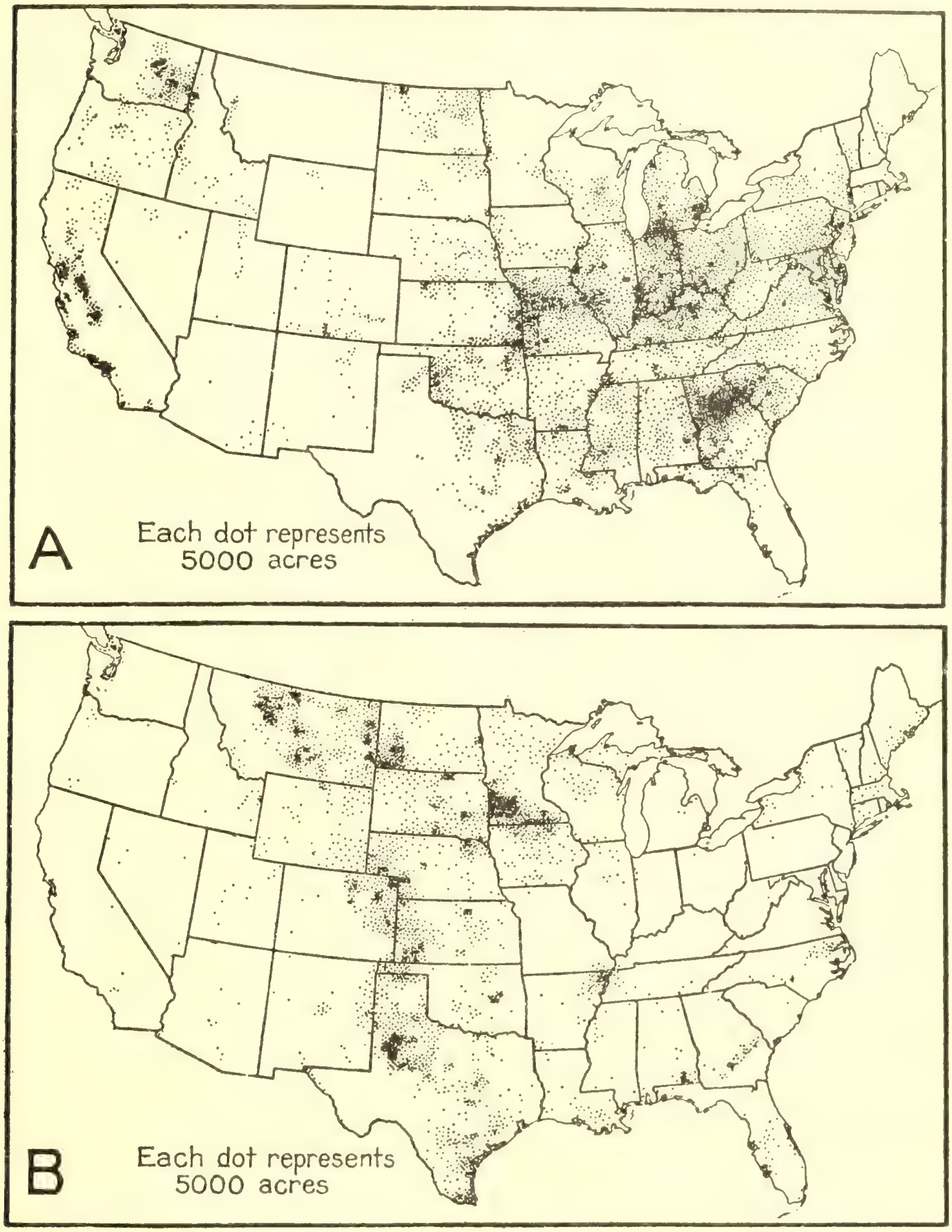
A
Each dot represents 5000 acres
B
Each dot represents 5000 acres

FIGURE 2.—Maps showing for period of 1919–24 decreases and increases in acreage of all harvested crops: A, decreases; B, increases (based on Census data).

The effect of this expansion on the use of wood is an interesting study. The small all-wood house apparently uses as much lumber as ever. But the all-wood house is not as common as it once was. There are more materials to choose from. In a six-room house that would require 20,000 feet of lumber, brick veneer may displace 2,800 feet of 10-inch siding, or fiber board may displace 3,000 feet of lumber for sheathing; nor does this take any account of the materials that may displace wood lath and shingles, which are not measured as lumber.

In multifamily housing the displacement of lumber by other materials to date has been even more pronounced than in the single-family dwelling. This type, which has developed almost entirely since 1912, made up some 50 percent of new housing by 1928. New multifamily housing is quite generally either of masonry-wall or all-

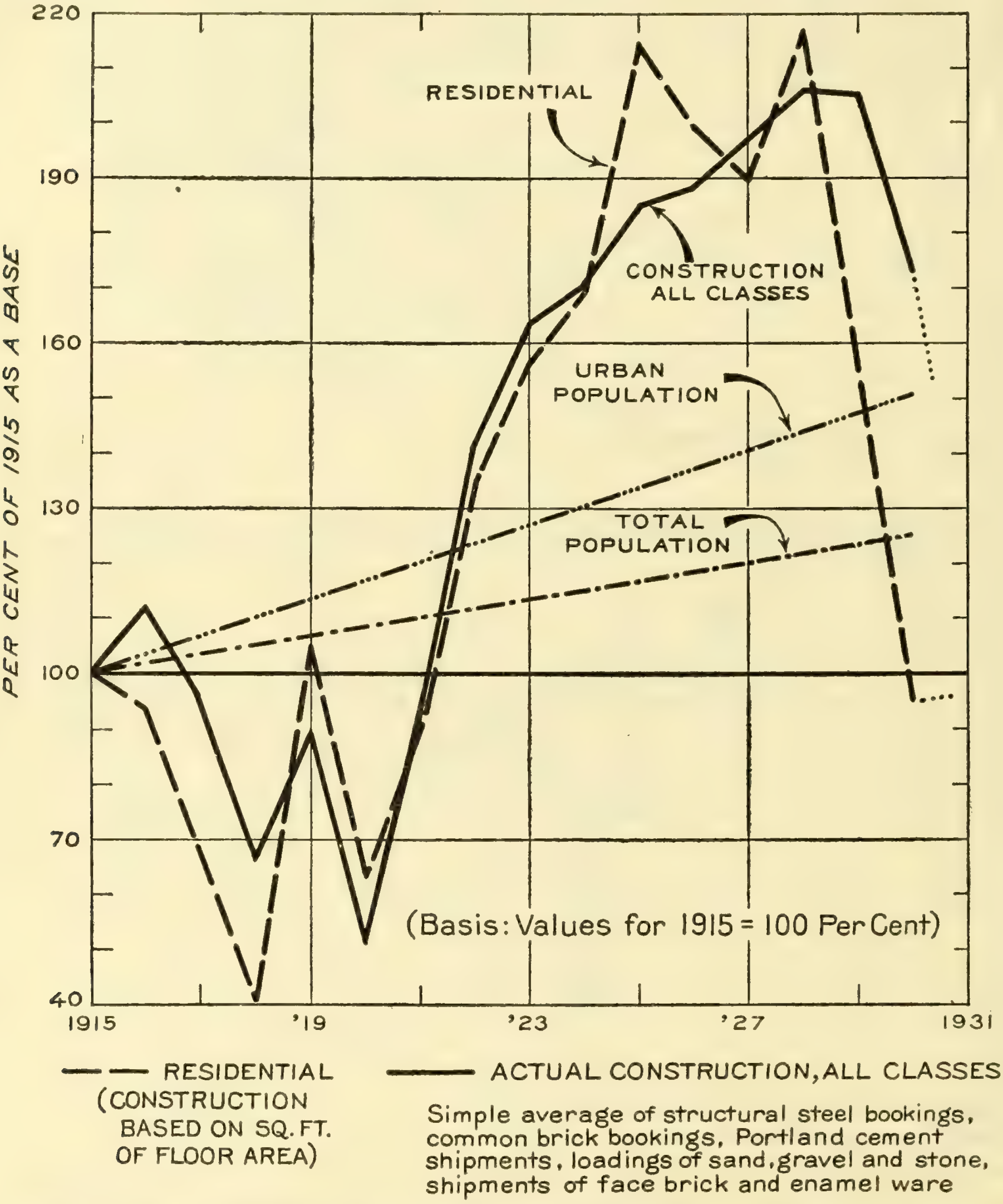

FIGURE 3.—Construction trends: Residential and all classes as related to urban and total population.

fireproof construction, and involves a reduction in floor area per person. It is estimated that use of other materials and reduction of floor area in multifamily housing reduced lumber requirements for total new housing in 1928 by 20 or 25 percent per family as compared with 1912. If multifamily housing alone can account for such a decline, 25 percent would be a conservative estimate for the relative displacement of lumber in single- and multiple-unit urban residential construction during the period considered.

On the basis of 20,000 board feet of lumber for the average single-family dwelling of 1,500 square feet floor area, the lumber requirements for 700,000 such units would be 14 billion board feet, and about 15 percent for repairs would make an estimated total annual requirement of 16 billion board feet. But reduction by a factor of 25 percent, as explained above, leaves an actual lumber requirement of 12 billion board feet for urban residential construction in 1928, as set up in table 3. The 1912 estimate of 9 billion board feet is based on residential construction of some 400,000 family units, considering only a small percentage as represented by multifamily housing of fireproof construction.

URBAN NONRESIDENTIAL

The above assumptions as to 1928 lumber consumption in rural construction and urban residentail construction leave a balance of 5.4 billion board feet in 1928 and 5.3 billion board feet in 1912 to be accounted for in urban construction other than residential. In 1928 construction for railroad companies (excluding car construction, which comes under factory consumption, and ties, which are reported separately) accounted for a billion board feet. Commercial, educational, and public buildings accounted for another billion board feet. There is left 3.4 billion board feet for wharves, highways, engineering works, and all miscellaneous construction. While the estimated lumber consumption in all nonresidential construction was about the same in 1928 as in 1912, records show that the 1928 volume of construction was twice that of 1912. That is, relative lumber consumption in this field was reduced one half by the use of other materials.

LUMBER CONSUMPTION IN FACTORY PRODUCTS

Lumber consumed in fabricated products or by wood-using industries ranges from one fourth to one third of our total lumber consumption. Requirements in this field for 1928 were only a billion feet below the 1912 figure, a decrease of less than 8 percent. The statistics for comparison, principally from Forest Service studies in the wood-using industries, are given in table 4.

TABLE 4.—*Lumber consumed in fabricated products and by wood-using industries. 1912 and 1928*

Products	1912	1928
	M ft. b.m.	*M ft. b.m.*
Boxes and crates	4, 550, 016	4, 981, 230
Car construction	1, 262, 090	1, 009, 408
Furniture	944, 678	1, 198, 612
Vehicles and vehicle parts:		
Nonmotor	569, 144	80, 841
Motor	170, 000	867, 875
Total of 4 principal industries	7, 495, 928	8, 137, 966
Woodenware, novelties, and dairymen's, poulterers', and apiarists' supplies	405, 286	183, 336
Agricultural implements	321, 239	142, 943
Chairs and chair stock	289, 791	165, 392
Handles	280, 235	124, 654
Musical instruments	260, 195	107, 502
Tanks and silos	225, 620	66, 328
Ship and boat building	199, 598	128, 342
Fixtures	187, 133	130, 030
Caskets and coffins	153, 395	156, 108
Refrigerators and kitchen cabinets	137, 616	145, 745
Matches and toothpicks	85, 442	123, 426

TABLE 4.—*Lumber consumed in fabricated products and by wood-using industries, 1912 and 1928*—Continued

Products	1912	1928
	M ft. b.m.	*M ft. b.m.*
Laundry appliances	79,502	38,674
Shade and map rollers	79,292	24,236
Paving material and conduits	76,067	3,350
Trunks and valises	74,668	21,346
Machine construction	69,459	39,627
Boot and shoe findings	66,240	48,742
Picture frames and moldings	65,478	20,947
Shutters, spools, and bobbins	65,148	44,022
Tobacco boxes	64,127	38,429
Sewing machines	59,947	12,760
Pumps and wood pipe	55,827	10,831
Pulleys and conveyors	35,863	900
Toys	28,927	39,410
Gates and fencing	27,451	1,572
Sporting and athletic goods	25,192	29,973
Patterns and flasks	24,299	29,996
Bungs and faucets	21,112	2,980
Plumbers' woodwork	20,313	16,273
Pencils and pen holders	20,041	39,982
Electrical machinery and apparatus	18,189	66,750
Mine equipment	16,988	22
Professional and scientific instruments	15,030	15,510
Brushes	12,879	17,033
Dowels	11,981	15,087
Elevators	10,019	46
Saddles and harness	9,218	751
Playground equipment	9,065	4,672
Butchers' blocks and skewers	8,197	4,888
Clocks	7,894	3,511
Signs and supplies	6,888	48,597
Printing material	5,325	5,984
Weighing apparatus	5,022	19
Whips, canes, and umbrella sticks	4,947	1,250
Brooms and carpet sweepers	2,277	28,452
Firearms	2,094	1,741
Artificial limbs	687	698
Tobacco pipes	490	1,411
Airplanes	74	9,044
Motion pictures and theatrical scenery	------------	16,223
Total of 50 minor industries	3,651,767	2,179,545
Total, all uses	11,147,695	10,317,511

The first four items—boxes and crates, car construction, furniture, and vehicles—represent roughly 80 percent of the total factory consumption for 1928. Requirements for these 4 increased 9 percent from 1912 to 1928, whereas requirements for the other 50 items, which account for only 20 percent of total consumption, decreased about 1.5 billion feet, or, roughly, 40 percent.

BOXES AND CRATES

Consumption of lumber for boxes and crates is by far the largest item in factory consumption of lumber, and in 1928 it amounted to nearly half the total. The 1928 consumption, while 10 percent greater than that in 1912, represents a decline of 18 percent from a peak of 6 billion board feet in 1914, and this despite a 25 percent increase since 1918 in tonnage of package freight. The competition of fiber boxes accounts for the difference.

Competition between lumber and fiber board for boxes rests chiefly on costs to the user. The average wooden box weighs about three times as much as a fiber box of the same size. Freight and handling charges on the wooden box, however, may be somewhat less than three times what they are on the fiber box, because the former averages larger and distributes the charges over larger contents. Improvements in design and construction have reduced the weight of wooden boxes about 25 percent in the last 10 years.

Further reduction could be made by more general application of information now available, but this would not materially broaden the field of wooden containers, as the main reduction in weight would come in the large sizes where there is as yet little competition from fiber. Changes that are taking place in transportation and handling methods favor the fiber box. From present indications it does not seem likely that lumber requirements for boxes and crates will go above the 1928 figure, and a decline is not improbable.

CAR CONSTRUCTION

The use of lumber in railroad car construction in 1928 showed a decline of 252,682,000 board feet, or 20 percent, as compared with 1912. This was most likely due to a lesser volume of construction rather than to disuse of wood as such. That freight-car construction fluctuates violently is shown by such figures as 335,000 cars built in 1905 and 65,000 in 1908; 190,000 in 1909 and 98,000 in 1910; 180,000 in 1912 and 80,000 in 1914; 98,000 in 1925 and 72,400 in 1927. There has been a great change in type of freight-car construction as affecting consumption of lumber, but most of this change developed prior to 1912. The 275,000 all-wood freight cars built in 1905 constituted 82 percent of all cars; in 1910 the 38,000 all-wood cars were only 39 percent; in 1912, 8,500 such cars were 4.7 percent; in 1925, 7,700 amounted to 7.9 percent; and in 1927, the 350 all-wood cars made up less than 0.5 percent of the total.[3] But in the part-wood freight car the changes in design that are being made constantly are not greatly changing the average wood consumption per car, which in 1912 was about 2,000 feet. Passenger cars, which are few in number as compared with freight cars, show a similar trend away from wood construction

FURNITURE

Consumption of lumber for furniture increased by more than a quarter of a billion board feet from 1912 to 1928, or 25 per cent. This is not so far out of line with the increase in population as to indicate increasing displacement of lumber by other materials.

More recent statistics from the Census Bureau throw valuable light on the trend as between wood and metal furniture. From 1925 to 1929 metal furniture increased 17½ percent in factory value, while wood furniture (including fiber, rattan, reed, and willow) made a 10 percent gain. The entire gain for metal was in furniture and fixtures for offices, stores, and public buildings, and for laboratories, hospitals, barber shops, and the like. The use of metal actually fell off 31 percent in factory value in household furniture, while use of wood increased 7 percent.

Metal furniture made up only 5 percent of the value of household furniture in 1929. On the other hand, it contributed one third of the value of furniture and fixtures not for household use, and here it had held its own for several years.

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[3] From Report No. 117, U.S. Department of Agriculture.

MINOR FACTORY ITEMS

The more conspicuous changes in minor factory items have occurred as the result of social and economic changes and in many instances are largely compensatory. For example, the development of the automobile and motor truck vastly curtailed buggy and wagon requirements, but in so doing it actually increased the use of wood. In fact, most of these developments indicate, not the direct competition of other materials with wood, but rather a change in services which producers of lumber and wood products may or may not have been prepared to meet.

In some of the most modern and popular items, an upward trend of wood consumption as between 1912 and 1928 may be confusing. Thus, the annual production of motor vehicles increased 21 percent from 1924 to 1928, but lumber consumption in motor vehicles dropped 4 percent, indicating a decline in amount of lumber per vehicle. Similarly, while consumption of lumber for airplanes has increased since 1912, the amount of wood per plane has decreased in favor of other materials.

The amount of plumbing has increased from 1912 to 1928, but the use of lumber for plumber's work has decreased, as table 4 shows. Manufacture of laundry appliances has more than doubled during the period, but the amount of lumber used in such appliances shrunk one half. The same tendencies may be even more pronounced in other products.

TENTATIVE NORMAL LUMBER REQUIREMENTS

Table 5 presents an estimate of normal annual lumber requirements for the country in its present stage of general development. The total arrived at is 31 to 34 billion feet. By normal requirements are to be understood the volume of consumption that may logically be expected when general economic conditions are such that the country is conscious neither of depression nor of unusual prosperity. It thus needs no proof that normal consumption will not be attained under the stress of the existing general depression, or the agricultural depression of earlier origin, which held rural construction below normal while industrial expansion was pushing urban construction far above normal.

TABLE 5.—*Estimated normal lumber consumption as of 1930 in comparison with totals for 1912 and 1928*

Class of use	1912	1928	Estimated normal 1930
	Billion ft.b.m.	*Billion ft.b.m.*	*Billion ft.b.m.*
Rural construction	15.0	5.5	10.0
Urban residential	9.0	12.0	6–8.0
Urban nonresidential	5.3	5.4	3–3.5
Sash, doors, and millwork	2.5	3.3	2–2.5
Factory products	11.2	10.3	10.0
Total	43.0	36.5	31–34.0

For the sake of the argument, however, let the normal present lumber requirements estimated in the table be assumed as a base line. The translation of these figures into normal long-time trends will depend very much on such influences as population, national wealth, and economic organization. Stabilization of population, changes in design and construction practices, the use of new materials, multifamily housing, and changes to extensive farming in some regions and to intensive in others will have a direct effect on normal lumber consumption for residential and farm building construction. Deviations from normal in one line of consumption may have much or little effect in another. Separate consideration of each major line of consumption is necessary, both as to direction of trend and percentage of total volume.

With a return of normal agricultural conditions there is a prospective increase of some 5 billion board feet over the 1928 rural lumber consumption. Is the currently reported city-to-farm movement likely to add appreciably to this potential market recovery? If recovery of urban residential construction involves a return to a lower price class, where the all-wood house has predominated, how will that be reflected in lumber consumption? The answer to such questions would shed much-needed light on future lumber requirements. Indications point to a steadily declining birth rate and a national population figure approaching stability between 1950 and 1970. A prospective increase in population of only 10 million persons from 1930 to 1940 would require proportionately less living accommodations than the 16-million increase from 1920 to 1930. Against this trend the increasing age of existing construction is to be considered. The number of dwellings has doubled in the 40 years since 1890, so that in the greater proportion of dwellings, the replacement factor has not had time to develop. A 60-year replacement factor, for example, applied to present dwelling accommodations would eventually set up a requirement, even with a stable population, for some 450,000 new family units annually, which was approximately the prewar rate.

HARDWOODS VERSUS SOFTWOODS

The declining consumption of lumber is reflected about equally by hardwoods and softwoods since 1906, as shown in table 1. From 1919 to 1928 hardwoods represented some 19 percent of total lumber consumed, as against perhaps 23 percent in the period 1909 to 1918. Much the same factors are at work in both hardwood and softwood consumption, although perhaps not to the same degree in specific cases. Changing rural demand would no doubt affect softwoods more than hardwoods, as would also the use of brick veneer, stucco, or other exteriors in place of wood in urban residential construction. On the other hand, the sustained use of wood in furniture manufacture means more in terms of hardwood than of softwood requirements.

There is also a factor of competition between hardwoods and softwoods. It is known that in the motor vehicle industry softwoods have displaced hardwoods for some purposes. The trend to upholstered furniture has meant some use of softwoods in place of hardwoods. Competition in wood flooring exists not only between different hardwoods, such as maple and oak, but also between hardwoods and softwoods.

The foregoing are only a few of the factors which must be seriously studied before future lumber requirements can be predicted with a satisfactory degree of assurance.

PULPWOOD REQUIREMENTS

STATISTICAL

Wood is today the preeminent raw material for the manufacture of paper, boards, and other fiber products, a fact that is clearly shown by table 6.

Attempts have been made from time to time, and are still being made, to pulp other fibrous plants, both cultivated and wild. Esparto, straws, bagasse, and cornstalks are being used with varying degrees of success. But wood is the most compact form of cellulose fiber that exists in nature and is hence the cheapest and easiest raw material to handle. Wood pulp was first used as a substitute for rags in making paper only 70 years ago and today about 85 per cent of our paper has its origin in the forests.

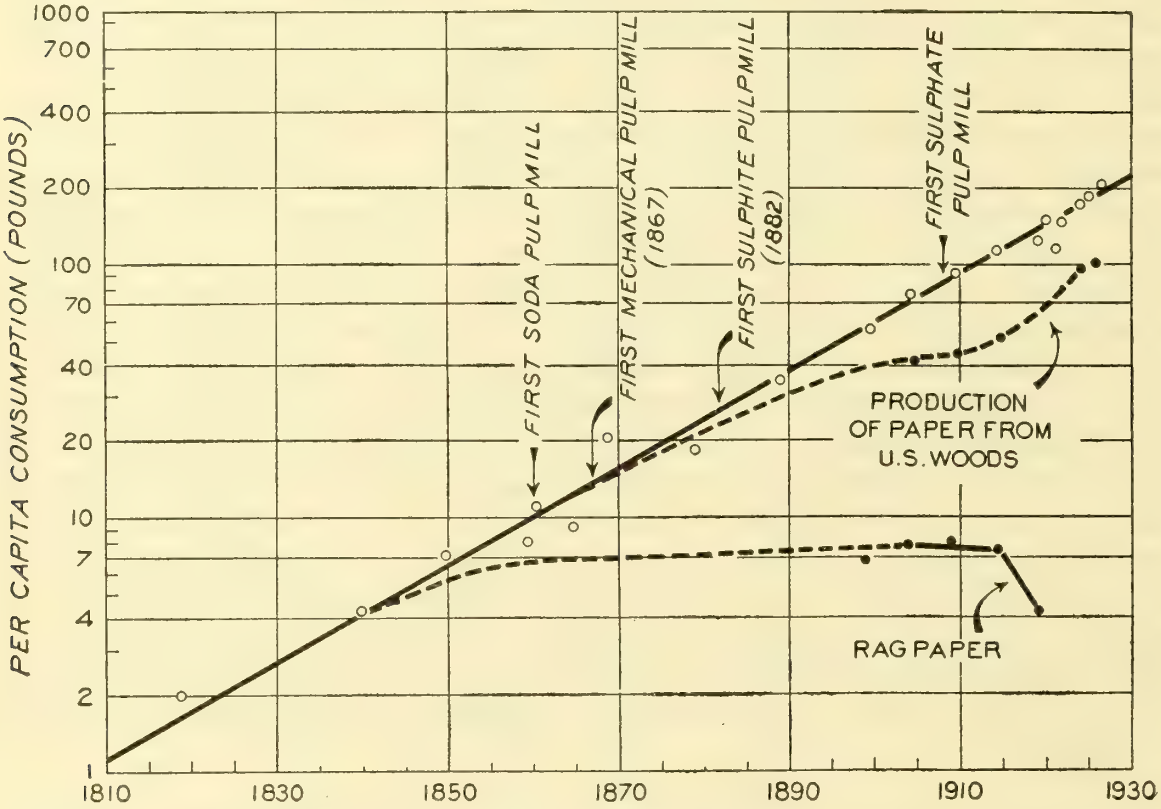

FIGURE 4.—Per capita consumption of paper and boards, as related to use of wood and rags

Figure 4, plotted on logarithmic ordinates, shows that the trend of per capita consumption of paper has maintained a uniform rate of increase over a 120-year period, during which time wood pulp has displaced rags as the chief raw material, and domestic woods have failed to supply all our pulpwood requirements. Such a record of increasing use cannot be set aside, even though current consumption may indicate a change in trend. Increasing per capita consumption, together with increasing population, has brought our total paper consumption to 12¼ million tons in 1930 as shown in table 7.

TABLE 6.—*Raw materials consumed in United States paper manufacture*

Calendar year	Wood pulp [1]	Rags	Paper stock	Manila stock	Straw	All other	Total raw materials	Total paper produced
	Short tons	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*	*Short tons*
1879	22,570	200,005	87,840	84,786	245,838	1,218	642,257	452,107
1889	349,917	246,892	139,061	524,862	355,131	------	1,615,863	934,611
1899	1,172,880	234,514	356,193	99,301	367,305	------	2,230,193	2,167,593
1904	2,018,764	294,552	588,543	107,029	304,585	------	3,313,473	3,106,696
1909	2,826,591	357,470	983,882	117,080	303,137	29,422	4,617,582	4,216,708
1914	3,490,123	361,667	1,509,981	121,170	307,839	97,276	5,888,056	5,270,047
1919	4,019,696	277,849	1,854,386	116,994	353,399	106,850	6,729,174	6,190,361
1929	6,289,318	739,422	3,841,942	128,800	575,263	[2] 626,812	12,201,557	11,140,235

[1] Production: exports and imports, not reported, are assumed to be equal.
[2] Reported as clay, rosin sizing, rosin, and casein.

Source: Bureau of the Census.

TABLE 7.—*Paper: Consumption by kinds and per capita, specified years beginning 1810* [1]

Year	Newsprint		Book		Boards		Wrapping	
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent
	Tons		*Tons*		*Tons*		*Tons*	
1899	569,000	26	314,000	15	394,000	18	535,000	25
1904	883,000	29	495,000	16	521,000	17	644,000	21
1909	1,159,000	27	689,000	16	883,000	21	763,000	18
1914	1,576,000	29	926,000	17	1,292,000	24	892,000	16
1917	1,824,000	29	846,000	14	1,805,000	29	814,000	13
1918	1,760,000	28	800,000	13	1,927,000	30	859,000	13
1919	1,892,000	29	838,000	13	1,940,000	30	825,000	13
1920	2,196,000	28	1,060,000	13	2,301,000	29	1,003,000	13
1921	2,002,000	33	707,000	11	1,641,000	27	770,000	13
1922	2,451,000	31	968,000	12	2,154,000	27	1,059,000	13
1923	2,814,000	30	1,235,000	13	2,802,000	30	1,177,000	13
1925	3,073,000	29	1,365,000	13	3,290,000	31	1,287,000	12
1926	3,517,000	30	1,408,000	12	3,637,000	31	1,435,000	12
1927	3,492,000	29	1,265,000	11	3,737,000	31	1,515,000	13
1928	3,561,000	29	1,321,000	11	4,009,000	32	1,457,000	12
1929	3,813,000	29	1,471,000	11	4,398,000	33	1,586,000	12
1930	3,496,000	28	1,370,000	11	4,014,000	33	1,556,000	13

[1] Imports added to United States production and domestic exports deducted.

TABLE 7.—*Paper: Consumption by kinds and per capita, specified years beginning 1810*—Continued

Year	Fine		All other		All kinds, quantity	Per capita, pounds
	Quantity	Percent	Quantity	Percent		
	Tons		*Tons*		*Tons*	
1810					[2] 3,000	1
1819					[2] 12,000	2
1839					[2] 38,000	4
1849					[2] 78,000	7
1859					[2] 127,000	8
1869					391,000	20
1879					457,000	18
1889					1,121,000	36
1899	113,000	5	233,000	11	2,158,000	57
1904	142,000	5	365,000	12	3,050,000	74
1909	193,000	5	537,000	13	4,224,000	93
1914	244,000	4	566,000	10	5,496,000	112
1917	276,000	4	691,000	11	6,256,000	122
1918	348,000	5	693,000	11	6,387,000	123
1919	306,000	5	692,000	10	6,493,000	124
1920	371,000	5	930,000	12	7,861,000	148
1921	230,000	4	704,000	12	6,054,000	112
1922	356,000	4	1,015,000	13	8,003,000	146
1923	374,000	4	938,000	10	9,340,000	167
1925	472,000	5	1,103,000	10	10,590,000	184
1926	495,000	4	1,315,000	11	11,807,000	203
1927	502,000	4	1,404,000	12	11,915,000	202
1928	538,000	4	1,562,000	12	12,448,000	208
1929	593,000	4	1,490,000	11	13,351,000	220
1930	564,000	5	1,251,000	10	12,251,000	199

[2] Domestic production only, value of exports and imports being approximately equal. No data for 1829.

A computed table based on data credited in the tables of compiled record. Printed as table 3, U.S.D.A. Bulletin 1241, 1810–1922. Tons of 2,000 pounds.

ANALYSIS OF TRENDS IN PAPER CONSUMPTION

The products designated as paper fall into six general classes—fine, book, newsprint, wrapping, boards, and all other. Table 7 and figure 5 afford a comparison of these classes in relation to total use.

NEWSPRINT

Of all papers newsprint is the most important, being exceeded in volume only by boards. Demand for newsprint for newspaper publication is concentrated in the large cities, nearly 90 percent of the total production being consumed by 15 percent of our dailies.[4] Total consumption of newsprint increased 60 percent from 1920 to 1930, and since newspaper circulation increased only 37 percent in that period, [5] it is evident that size of issue is also a large factor in consumption. This is borne out by figure 6 which shows increasing bulk of newspapers and increasing pounds per capita following same general trend. Numbers of pages are based on 1 week's figures per year for 10 papers taken at random from different sections of the country. They are not necessarily the average for the country, but are considered as indicative.

Back of the growth in newspaper circulation are, of course, the factors of literacy and population increase, more particularly in urban centers. Urban population increase in the United States during the last decade was the largest it has ever been. As the increase becomes less that factor will diminish.

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[4] From a report by H. A. Laird, manager, traffic department, Chicago Tribune, 1930.
[5] From a report by R. S. Kellogg of the Newsprint Service Bureau, Oct. 27, 1931.

What the future size of our newspapers will be is more difficult to estimate than is the probable circulation trend. Advertising largely controls the number of pages, and reports indicate that a decline in advertising since 1926 has reduced the size of newspapers from a maximum presumably occurring in that year. Advertising will in all probability recover from the depression along with other commercial activities, but there is now the question of competition between forms of advertising. H. A. Laird has estimated that the newspapers' share of the total spent for advertising in 1922 was 62½ percent, but only 46 percent in 1929.

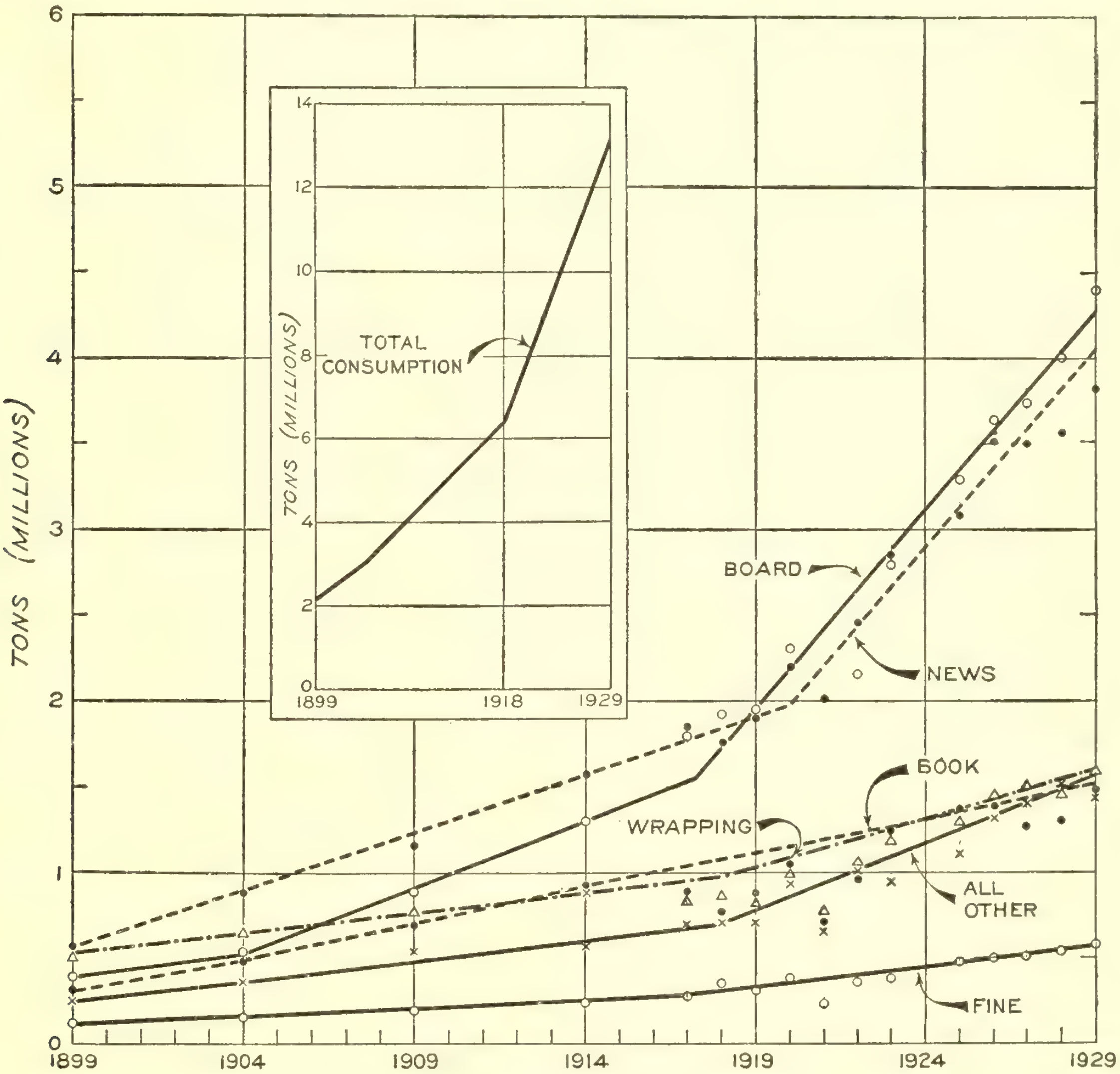

FIGURE 5.—Paper consumption by kinds.

BOARDS

On a gross tonnage basis boards have taken first place from newsprint. (See fig. 5.) They fall far below newsprint, however, in pulp requirements. Only some 20 percent of boards, by weight, is new pulp, the remainder being supplied chiefly by reuse of waste paper.

Container board is the largest item, and there is reason to believe that the saturation point for such boards has not yet been reached. The increasing demand for fiber containers is clearly due to the far-reaching change from bulk to package handling of commodities. Package freight originating on class 1 railroads, for example, increased more than 25 per cent from 1920 to 1928, a time when there was no increase in total freight originating on these roads. Further increase in the use of fiber containers is favored by changes in transportation and handling methods which reduce shipping hazards, by the economies possible with prepacking of merchandise, and by the probability that research will further improve and strengthen the fiber box.

Fiber boards as construction material are a comparatively late development, but their use for insulation against heat, cold, and sound, for concrete forms, and for various temporary purposes has grown rapidly. Boards of this character, aggregating more than 120,000 tons in 1927, are not included in the statistics for paper consumption. Some of them are made of straw, some of cornstalks, some of cane, and some of wood. A demand for them has been established, and the prospects are that their use will increase.

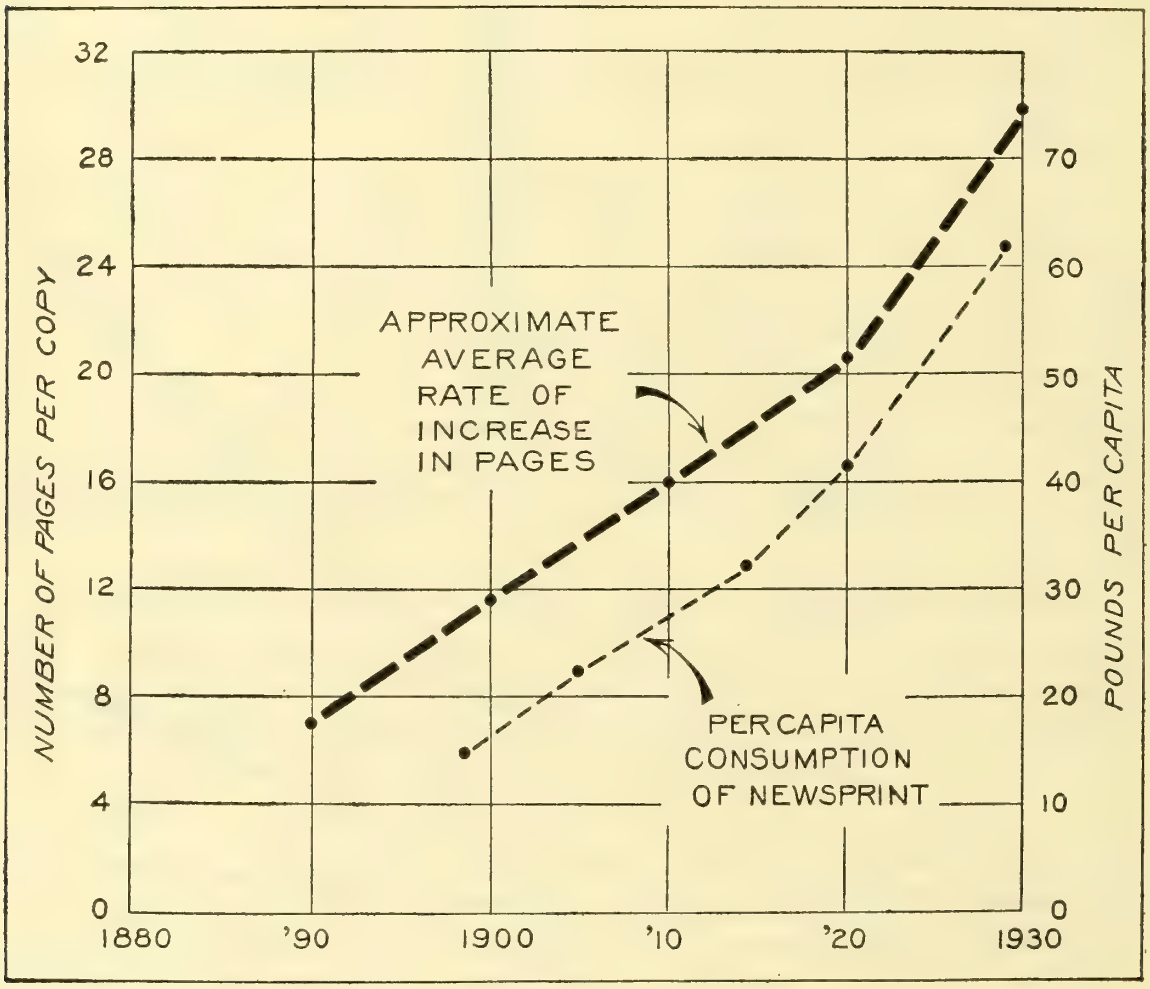

FIGURE 6.—Increase in number of pages per copy of daily papers since 1880.

OTHER PAPERS

Fine papers constitute only about 5 percent of all pulp products and have held closely to this proportion for 30 years. Consumption of both book and wrapping papers has doubled in the last 20 years, but the percentage fell from 16 or 18 percent of total paper consumption in 1909 to about 12 percent in 1929. All other paper consumption has held to about 12 percent of the total for the past 30 years.

FUTURE PAPER REQUIREMENTS

The forecasting of paper requirements presents in some respects an even more difficult problem than that of lumber requirements. In the attempt to anticipate lumber requirements the factors dealt with have more or less stability, once they are definitely set up. That there should be a dwelling for every family, for example, would probably be generally accepted, and there is little point in considering a prospect of two dwellings per family. Size of family and size of dwelling are changing, but reasons for the changes are evident and the trends can be set up as normal.

On the other hand, there is as yet no accepted standard for the number and quantity of newspapers per family. In Washington, D.C., the average for the city is 2½ daily papers per family, whereas rural sections can no doubt be found where there are no daily papers. Will the saturation point be 1, 2, or more daily papers per family? Further, how large is the daily paper to be? Similar questions may be raised as to books and magazines. There is still a large undeveloped field for all cultural paper products. Will it remain undeveloped?

Requirements for boards and probable new paper products are equally uncertain. There is no allotment per capita or per family that can be recognized as marking the saturation point, nor can anyone say when such a point will be reached.

Referring again to figure 5, it is seen that consumption of all papers increased at a greater rate after 1920 than before. If the trend after 1920 represents a new "normal," its continuation would suggest a total paper consumption of 28 million tons by 1950. On the other hand, the post-war increases may have been abnormal. Decline in consumption since 1929 is looked upon by some as marking a return to a lower basis. What that means is not at all definite, since paper consumption has certainly not suffered as severely in the present depression as have manufactures generally. A return to pre-war trends, however, would indicate a total paper consumption in the United States considerably below 28 million tons by 1950. Bernard Navarre, president of the Association of Paper Manufacturers of France, in a paper presented at the International Forestry Congress in Paris, in 1931, predicted that in 30 years world paper consumption will increase from 20 million tons to 60 million tons. If the United States retains its relative position, this is a forecast of over 30 million tons annual consumption here by 1960. A report by Charles W. Boyce, of the American Paper and Pulp Association, in October 1931, suggests a 1950 paper consumption of 24 million tons and equivalent pulpwood requirements of 22 million cords.

For conversion of total paper consumption to the equivalent of pulpwood, the rough relation of 1 cord of wood to a ton of pulp may be assumed. This ratio is subject to some variation depending, for example, upon the proportion of waste paper reused and the proportion of such reuse to total consumption. With boards holding closely to the general trend since 1918, no great change in the conversion factor is in sight. Timber requirements for pulpwood must also take into account the use of waste wood, which is small thus far, representing only some 7½ percent of wood converted into pulp in the United States and some 3½ percent of our total pulpwood requirements.

RAYON AND CELLOPHANE

Besides pulp requirements for paper manufacture, there is a relatively small but rapidly growing pulp requirement for other cellulose products, of which the chief at present is rayon. Rayon is yet too new a product to permit its future pulp requirements to be estimated with any definiteness. Its status in only a few years has changed from that of "artificial silk" to a new textile in its own right, competing no longer with silk alone but also with cotton and even with wool.

The growth of the industry is outlined in the following paragraphs from Commerce Reports (of the Bureau of Foreign and Domestic Commerce) for March 21, 1932:

> In 1911 American rayon yarn output was calculated at 320,000 pounds. Ten years later, in 1921, production had expanded to 15,000,000 pounds. Even more impressive than the 144,350,000 pound output of 1931 is the fact that within the trade it is stated that actual production capacity as of July 1931 was nearly 195,000,000 pounds.
>
> Latest official records for the rayon industry of this country are those obtained in the 1929 census of manufacturers, revealing 28 producing plants as compared with only 19 in 1927, the date of the preceding census—practically a 50 percent expansion in 2 years. In the latter year there were 38,938 wage earners, with annual compensation totaling $44,704,000. The aggregate value of products was $149,276,000.

As to the amount of wood pulp used in the production of rayon in 1931, the following is quoted from the bulletin of the News Print Service Bureau for March 15, 1932:

> The best estimates available are to the effect that approximately 52,000 tons of wood pulp were used for rayon in the United States last year. This is 5 percent of the consumption of bleached sulphite pulp and 2.4 percent of the total consumption of sulphite pulp, bleached and unbleached combined.
>
> Estimates in the trade are to the effect that there were also made in the United States last year something like 80 million pounds of cellophane in which there was used perhaps 50,000 tons of bleached sulphite pulp.

Assuming that a like amount of sulphite pulp was used in our 1931 production of cellophane, the total pulp requirement for rayon and cellophane together may be estimated at 100,000 tons, which would represent about 5 percent of our sulphite pulp consumption and something like 10 percent of our domestic production of such pulp. How soon or how largely this estimate will be superseded remains to be seen.

IMPORTS IN RELATION TO PULPWOOD REQUIREMENTS

Imports are the largest single factor to be weighted in the conversion of pulp and paper consumption to domestic wood requirements. Table 8 shows what part of the imports have come to the United States as paper, what part as pulp, and what part as wood. Total requirements are here made to include our exports of paper in addition to home consumption. In 1899, 22 percent of the total requirements was supplied by foreign wood. The percentage increased steadily to 56 percent in 1925, and was 54 percent in 1930.

Table 8.—*Foreign contributions to United States paper requirements, specified years, beginning 1899*

Year	United States paper requirements in pulpwood equivalent			Imports from Canada [1]				
	Domestic consumption	Paper exports	Total	Pulpwood [2]	Wood pulp and its pulpwood equivalent		Paper and its pulpwood equivalent	
	Cords	*Cords*	*Cords*	*Cords*	*Tons*	*Cords*	*Tons*	*Cords*
1899	1, 950, 000	125, 000	2, 075, 000	369, 000	31, 511	51, 000	88	----------
1904	3, 259, 000	138, 000	3, 397, 000	574, 000	113, 585	183, 000	11, 879	6, 000
1909	4, 420, 000	152, 000	4, 572, 000	794, 000	164, 404	204, 000	16, 941	27, 000
1914	5, 886, 000	185, 000	6, 071, 000	830, 000	316, 735	422, 000	282, 279	378, 000
1917	6, 783, 000	478, 000	7, 261, 000	774, 000	438, 986	629, 000	497, 276	660, 000
1918	6, 366, 000	500, 000	6, 866, 000	745, 000	571, 675	973, 000	606, 132	805, 000
1919	6, 806, 000	620, 000	7, 426, 000	1, 032, 000	519, 212	853, 000	674, 963	856, 000
1920	8, 300, 000	433, 000	8, 733, 000	1, 099, 000	655, 144	1, 129, 000	720, 439	921, 000
1921	6, 649, 000	239, 000	6, 888, 000	817, 000	402, 846	681, 000	675, 136	880, 000
1922	9, 148, 000	235, 000	9, 383, 000	1, 050, 000	645, 416	1, 120, 000	926, 977	1, 204, 000
1923	9, 924, 000	189, 000	10, 113, 000	1, 236, 000	720, 726	1, 178, 000	1, 151, 489	1, 445, 000
1925	10, 733, 000	232, 000	10, 965, 000	1, 088, 000	880, 453	1, 438, 000	1, 354, 913	1, 709, 000
1926	12, 129, 000	212, 000	12, 341, 000	1, 277, 000	864, 876	1, 416, 000	1, 788, 099	2, 270, 000
1927	12, 197, 000	239, 000	12, 436, 000	1, 224, 000	776, 999	1, 288, 000	1, 897, 307	2, 414, 000
1928	12, 939, 000	273, 000	13, 212, 000	1, 409, 000	784, 981	1, 304, 000	2, 069, 833	2, 639, 000
1929	13, 780, 000	417, 000	14, 197, 000	1, 242, 000	802, 665	1, 313, 000	2, 359, 117	2, 957, 000
1930	13, 034, 000	370, 000	13, 404, 000	858, 000	735, 864	1, 179, 000	2, 170, 185	2, 721, 000

Year	Imports from Norway, Sweden, Finland, and Germany				Imports from all other countries				
	Wood pulp and its pulpwood equivalent		Paper and its pulpwood equivalent		Pulpwood	Wood pulp and its pulpwood equivalent		Paper and its pulpwood equivalent	
	Tons	*Cords*	*Tons*	*Cords*	*Cords*	*Tons*	*Cords*	*Tons*	*Cords*
1899	5, 494	11, 000	8, 564	15, 000	----------	312	1, 000	6, 919	11, 000
1904	43, 398	70, 000	929	1, 000	----------	5, 189	8, 000	59, 021	79, 000
1909	129, 365	258, 000	25, 411	36, 000	----------	13, 354	27, 000	12, 054	16, 000
1914	348, 940	705, 000	31, 189	54, 000	----------	9, 890	20, 000	12, 741	20, 000
1917	237, 390	461, 000	3, 698	6, 000	----------	1, 465	1, 000	16, 184	22, 000
1918	6, 534	13, 000	396	1, 000	----------	----------	----------	12, 449	18, 000
1919	113, 414	230, 000	922	1, 000	----------	3, 390	6, 000	7, 800	2, 000
1920	242, 253	462, 000	57, 671	72, 000	----------	8, 900	15, 000	15, 580	20, 000
1921	284, 980	527, 000	148, 482	200, 000	----------	9, 274	18, 000	18, 420	25, 000
1922	601, 765	1, 202, 000	169, 358	247, 000	----------	11, 054	21, 000	28, 800	41, 000
1923	639, 120	1, 195, 000	260, 212	341, 000	----------	23, 310	40, 000	32, 846	41, 000
1925	745, 747	1, 417, 000	164, 285	209, 000	----------	37, 414	70, 000	24, 124	28, 000
1926	829, 132	1, 593, 000	142, 280	181, 000	----------	41, 725	81, 000	32, 079	34, 000
1927	855, 404	1, 648, 000	171, 658	212, 000	----------	41, 365	80, 000	41, 782	43, 000
1928	923, 668	1, 770, 000	165, 046	203, 000	----------	46, 314	90, 000	44, 990	46, 000
1929	1, 050, 824	1, 998, 000	153, 250	177, 000	6, 000	34, 016	66, 000	42, 342	40, 000
1930	1, 065, 778	2, 005, 000	179, 207	211, 000	238, 000	28, 575	56, 000	42, 577	37, 000

PULPWOOD EQUIVALENT OF TOTAL IMPORTS

Year	From Canada		From Norway, Sweden, Finland and Germany		From all other countries		Total foreign contributions	Percentage of United States requirements
	Cords	*Percent*	*Cords*	*Percent*	*Cords*	*Percent*	*Cords*	*Percent*
1899	420, 000	92	26, 000	6	12, 000	2	458, 000	22
1904	763, 000	83	71, 000	8	87, 000	9	921, 000	27
1909	1, 025, 000	75	294, 000	22	43, 000	3	1, 362, 000	30
1914	1, 630, 000	67	759, 000	31	40, 000	2	2, 429, 000	40
1917	2, 063, 000	81	467, 000	18	23, 000	1	2, 553, 000	35
1918	2, 523, 000	98	14, 000	1	18, 000	1	2, 555, 000	37
1919	2, 741, 000	92	231, 000	8	8, 000	----------	2, 980, 000	40
1920	3, 149, 000	85	534, 000	14	35, 000	1	3, 718, 000	43
1921	2, 378, 000	76	727, 000	23	43, 000	1	3, 148, 000	46
1922	3, 374, 000	69	1, 449, 000	30	62, 000	1	4, 885, 000	52
1923	3, 859, 000	70	1, 536, 000	28	81, 000	2	5, 476, 000	54
1925	4, 235, 000	71	1, 626, 000	27	98, 000	2	5, 959, 000	54
1926	4, 963, 000	72	1, 774, 000	26	115, 000	2	6, 852, 000	56
1927	4, 926, 000	71	1, 860, 000	27	123, 000	2	6, 909, 000	56
1928	5, 352, 000	72	1, 973, 000	26	136, 000	2	7, 461, 000	56
1929	5, 512, 000	71	2, 175, 000	28	113, 000	1	7, 800, 000	55
1930	4, 759, 000	65	2, 215, 000	30	331, 000	5	7, 305, 000	54

[1] Includes Newfoundland and Labrador.
[2] Imported as such for consumption by mills in the United States.

A computed table based on data credited in the tables of compiled record. Combines table 27 and table 28, U.S.D.A. Bulletin 1241, 1899–1922. Tons of 2,000 pounds. Cords of 128 cubic feet.

If, according to Boyce's estimate, American paper consumption in 1950 is to be the equivalent of 22 million cords of wood, and if domestic wood hereafter supplies 45 percent of the total requirement, the consumption of domestic pulpwood in 1950 will be only 9.9 million cords. If domestic wood continues to lose ground in competition with foreign resources, the figure will be even less. However, with adequate timberlands of our own there is no justification for any plan that does not look to providing for total pulpwood requirements independent of imports.

The primary cause for rapid increase in our relative dependence upon foreign resources has been the insufficiency of pulpwood in our older spruce-pulp producing regions, that is, New England, New York, Pennsylvania, and the Lake States, to meet increased requirements. The industry has had to go to more distant sources, either at home or abroad. Figure 7 shows graphically how our newer regions have been developed from a comparatively small place in 1904 to supply half the domestic wood used in 1929. Consumption from this source increased nearly fourfold in the 10 years beginning in 1919. Even so, domestic wood was unable to hold its relative position in competition with imports, dropping from 60 percent of total requirements in 1919 to 45 percent in 1929.

Newer woods as well as newer regions occupy an increasing place in the domestic pulping industry, but without any great decrease in the relative amount of spruce in our total paper consumption. It is true that spruce wood, both domestic and imported, pulped in our own mills increased but little from 1904 to 1929, and furnished only 22 percent of our total wood requirements in 1929 as compared with 67 percent in 1904. (See fig. 8.) But assuming imports of pulp and paper to represent also requirements for spruce, which is more or less the case, then spruce supplied approximately 80 percent of our wood requirements in 1904, dropped to 70 percent in 1919, and has practically held that position since. The extent to which spruce continues to dominate the industry is sometimes lost sight of by considering only domestic pulp production.

In 1929 spruce represented some 46 percent of all wood consumed in domestic pulp production, hemlock 16 percent, pines 16 percent, and all other woods 22 percent. The use of hemlock may be taken to represent substittuion for spruce in the production of mechanical and sulphite pulps, and the use of pine to represent a shifting of pulp production to sulphate.

The relative shift to broader bases of supply is further illustrated by figure 9. There has been little change in the quantity of mechanical pulp made from domestic wood since 1904, but whereas this wood constituted 32 percent of total wood requirements in 1904, it was only 9 percent in 1929; in the same period dependence on foreign timber resources for mechanical pulp increased from 10 percent to 18 percent of the total requirement. Domestic wood for sulphite pulp made up 36 percent of our requirements in 1904 and only 19 percent in 1930, while dependence on foreign resources increased from 15 percent to 28 percent of the total. The situation is almost reversed in the sulphate field. Sulphate pulp represented only 2 percent of total pulpwood requirements in 1909, practically all imported. By 1923, imports of sulphate pulp represented 6 percent of total wood requirements, but domestic production had grown up to the same proportions. By 1930

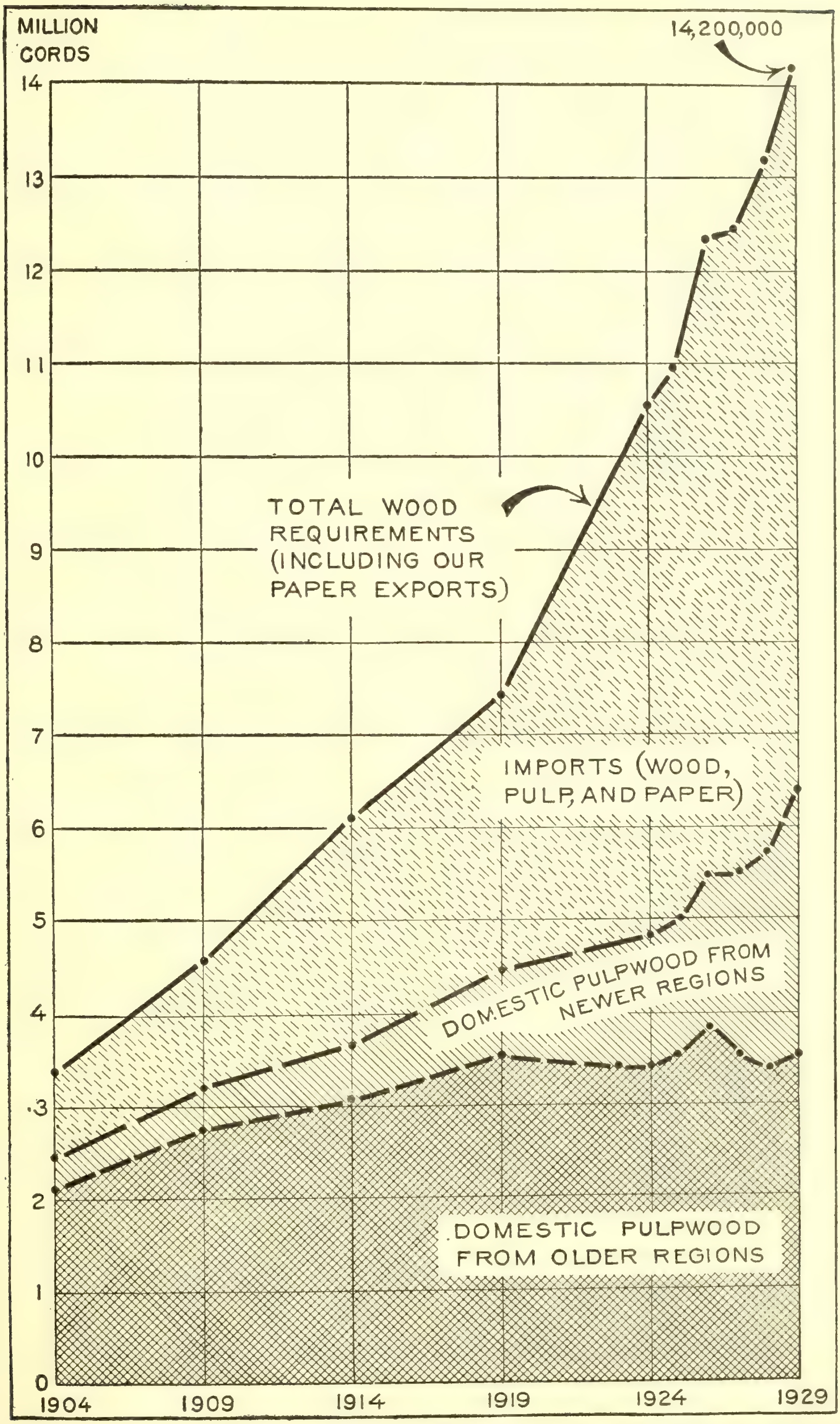

FIGURE 7.—Dependence on imports for our pulpwood requirements has increased despite development of new domestic sources.

domestic production had increased to 13 percent and imports were still only 6 percent of total requirements.

The significant fact illustrated by figure 9 is the importance of timber resources to our pulp and paper industry. Growth of domestic sulphate production in competition with imports is accounted for by the extension and adaptation of a pulping process to abundant wood resources of the South, and it goes far toward demonstrating that with an equally favorable raw-material situation domestic industry could compete successfully in the mechanical and sulphite fields also. That should be a sound objective, whether it means growing of the pulpwood species now preferred by industry or adapting the pulping process to utilize other domestic woods, or both.

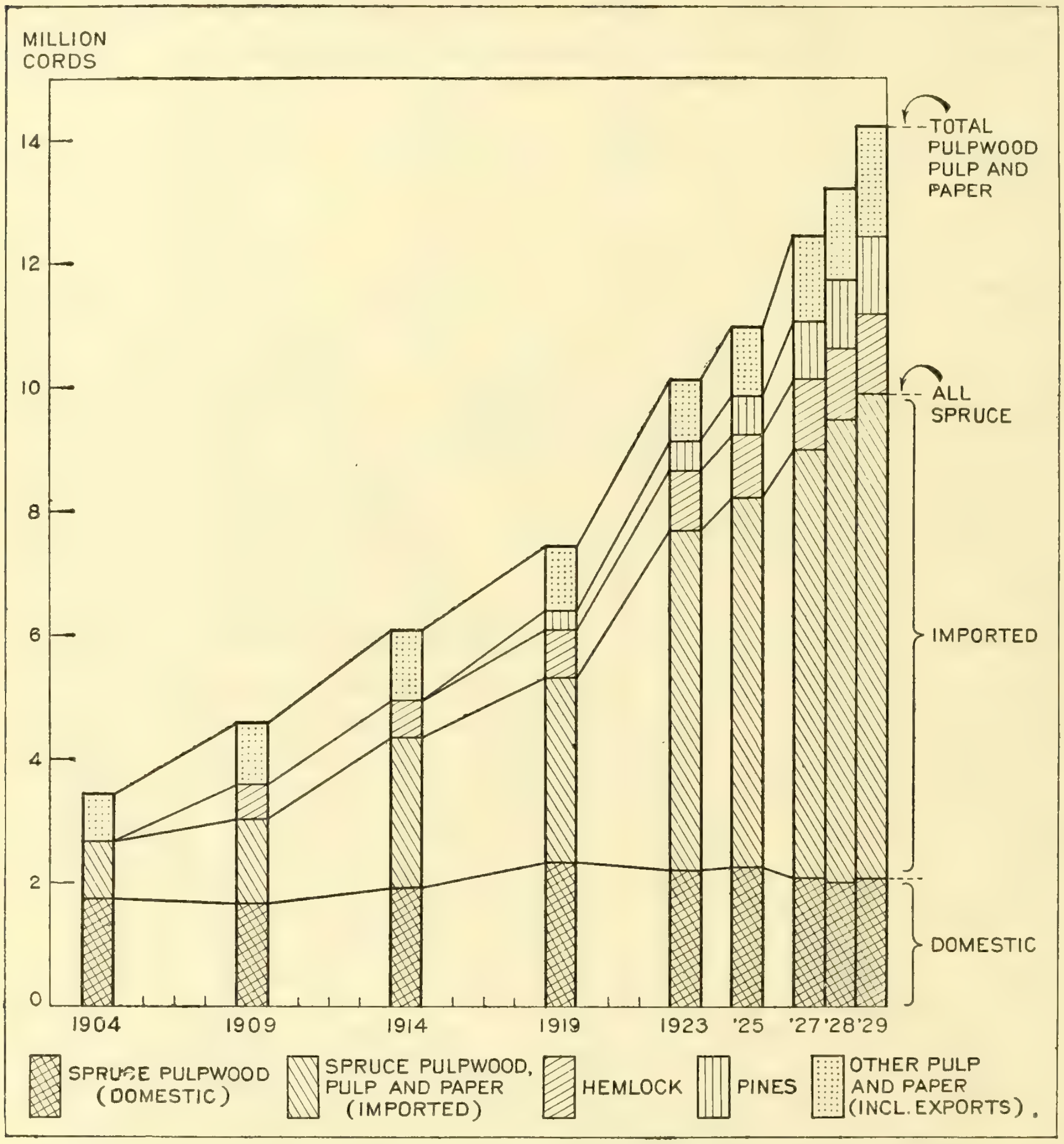

FIGURE 8.—Imports in relation to trends in pulpwood requirements—spruce versus other species. Spruce has dropped from 67 percent in 1904 to only 22 percent in 1929 of wood used in domestic production of pulp, but still made up 70 percent of total requirements in 1929 compared with 80 percent in 1904.

Development of the domestic industry provides a market for timber crops and employment for labor. Our present importation of the equivalent of 7 million cords of wood annually is equal to a timber crop from perhaps 7 million to 15 million acres, depending on growing conditions, and these figures may be doubled by 1950.

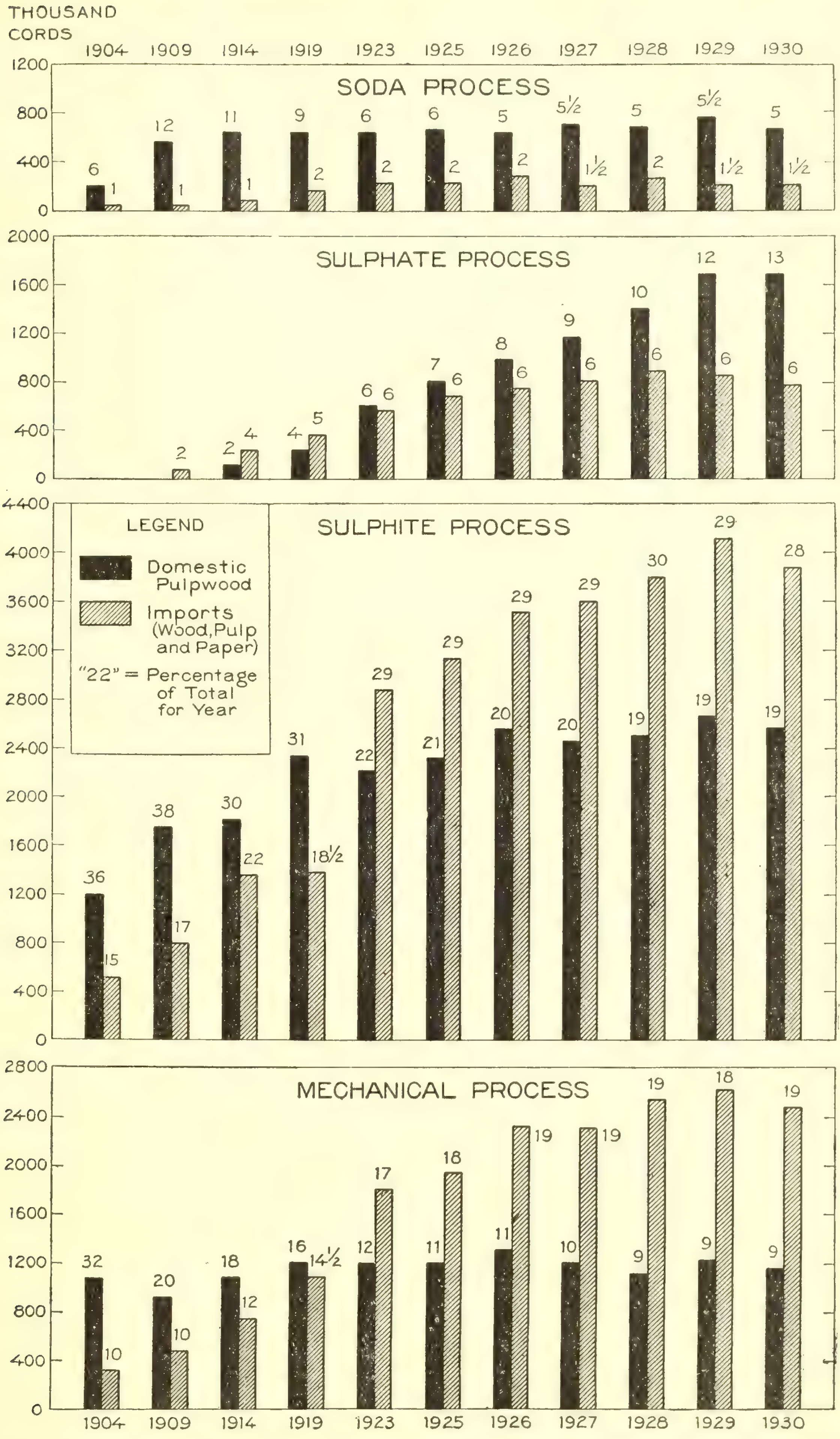

FIGURE 9.—The effect of ample supply of suitable wood is shown by the successful competition of domestic pulpwood with imports of wood, pulp, and paper in the sulphate field, contrasted with increasing dependence on imports for sulphite and mechanical pulps.

Pulpwood, pulp, and paper imports are shown in terms of wage earners employed in figure 10. The conversion is based on output per man in the production of both pulp and paper in the United States, as reported by the Bureau of the Census for 1929. Output per man has increased since then, but not enough to affect measurably the converting factor. Woods labor, which the census reports do not include, has also been taken into account on a basis of 300 cords of wood per man per year. This is all utilization labor, leaving the additional factor of labor in growing the timber crop.

On the above basis, our imports of foreign pulps, pulpwoods, and paper as of 1929 were equivalent to full-time employment for more than 70,000 wage earners, which is nearly half as many as were actually employed in the entire domestic industry. This import business has developed almost wholly since 1904, and most of it since 1919. The figure will increase as our paper requirements increase, unless with our domestic pulpwood resources better means are found to meet the competition of imports.

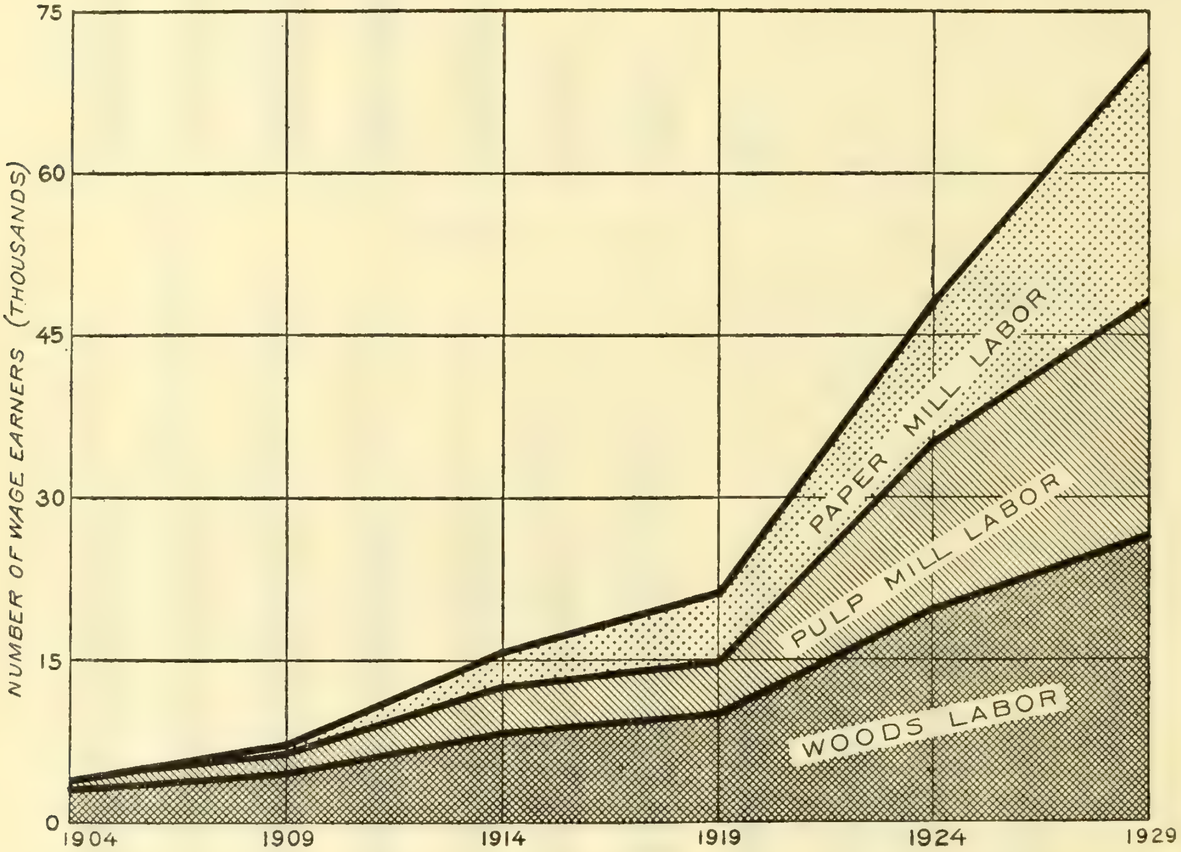

FIGURE 10.—Imports of wood, pulp, and paper converted to wage earners.

RAILROAD CROSSTIES

The number of crossties purchased during 1929 (including bridge and switch ties reduced to crosstie equivalents) amounted to 95,521,200 ties. This is the lowest for any year for which records are available from 1906 to 1929. (See table 9.)

There is considerable irregularity in the number purchased from year to year, so that it is difficult to show from the record just what the trend is, although it appears to be downward. The high figure of 1907 has not been reached since, nor does the average for the years 1923 to 1929 reach the average for the years prior to 1923. A downward trend can be explained by preservative treatments and mechanical protection of ties, and by decline in railroad construction.

According to the records of the American Railway Engineering Association, the average figure for renewals on the principal railroads was 261 ties per mile for the 5-year period ending with 1915. In 1929 the 5-year average was 180 ties per mile, marking a steady decline of 31 percent. It is not improbable that this trend may continue until, possibly by 1945 or 1950, the average annual requirement for replacements is less than 125 ties per mile. Requirements for several railroads are already below that figure.

The railroad mileage in the United States has decreased since 1916, as shown in table 10, but the total track mileage, including supplementary trackage, sidings, and yards, has increased about 3,000 miles per year since 1924.

TABLE 9.—*Recorded purchase of crossties, 1906–29*

Year	Ties purchased
	Number
1906	102,834,042
1907	153,703,000
1908	112,466,000
1909	123,751,000
1910	148,231,000
1911	135,053,000
1915	121,400,000
1923	135,976,117
1925	111,341,759
1927	113,708,292
1929	95,521,201

TABLE 10.—*Steam railway mileage in the United States, by 2-year periods, 1900–28* [1]

Year	Total miles of road	Total track mileage	2-year increases in total track mileage
1900	193,346		
1902	202,472		
1904	213,904		
1906	224,363		
1908	223,468		
1910	240,293	351,767	
1912	246,777	371,238	19,471
1914	252,105	387,208	15,970
1916	254,037	397,014	9,806
1918	253,529	402,343	5,329
1920	252,845	406,579	4,236
1922	250,413	409,359	2,780
1924	250,156	415,028	5,669
1926	249,138	421,341	6,313
1928	249,309	427,750	6,409

[1] From Interstate Commerce Commission reports.

It is impossible to say how long this rate of increase will continue, but the encroachments of automobiles, busses, and trucks upon rail business and the increasing use of trucks and busses by the railroads themselves make it very probable that new construction, together with the annual number of ties required for it, is due for an eventual or early decline.

Should tie renewals drop to 120 per mile annually by 1950, then 51 million ties will be required in that year to maintain the 1928 trackage of 427,750 miles. If the present increase of 3,000 miles per annum should be maintained, the 66,000 additional miles by 1950 would require replacement of 8 million ties annually, and the new construction that year at 3,000 ties per mile would itself require 9 million ties, making the total requirement for the year 1950 more than 68 million ties.

FUEL WOOD

Fuel wood is next to lumber in quantity and represents some 28 percent of the total timber consumption of the United States. Fuel wood cut is estimated at over 61 million cords as of 1929. Although this is a large figure, it is considerably less than earlier estimates, as might be expected in a mechanical age.

The decline in fuel wood consumption is largely a matter of changes in requirements and competition of other materials, paralleling somewhat the changes in lumber requirements. Perhaps the first great change in domestic fuel requirements came with the introduction of the base-burner and coal. Without attempting to list all changes chronologically, there may be mentioned gasoline and gas stoves for cooking, the furnace or central heating plant using coal, oil, and gas, and electricity with electric appliances. That these changes are still under way is shown in the recent advances in distribution of gas made possible by welded pipe. There were over 40 thousand miles of natural-gas trunk lines in 1929.

Considering wood as chiefly a domestic fuel, the extent of competition of other fuels is illustrated by an increase in domestic consumers of natural gas from roughly a million in 1909 to 5 million in 1929. Domestic consumption of bituminous coal increased from 46 million tons in 1909 to 82 million tons in 1927, the latest year for which this figure is available. The domestic consumption of anthracite coal was approximately 48 million tons in 1927.

It is impossible to arrive at actual displacement of wood by other fuels from information available, but the above figures are at least suggestive. At 7½ tons per dwelling, the domestic coal consumption of 130 million tons in 1927 would supply fuel for over 17 million dwellings, or roughly the equivalent of all urban dwellings. This coal consumption was supplemented by artificial and natural gas, fuel oil, and other minor fuels. The typical domestic consumer consumes more than one fuel; that is, there is an overlapping in number of consumers of coal, oil, gas, electricity, and wood. Furthermore, coal, oil, and gas compete with one another just as they compete with wood.

The decline in fuel wood requirements has been very largely in the urban field. And since consumption of wood for fuel is now largely confined to rural sections where its use will most likely be maintained, requirements may be approaching a minimum at current figures. The general opinion is that consumption of fuel wood has actually increased since 1929, due to present economic conditions. This may be only temporary, but it is unmistakable evidence of advantages in having a supply of fuel wood available.

NAVAL STORES

The term "Naval Stores" applies to rosin and spirits of turpentine obtained from either living trees or the resin-impregnated stumpwood and heartwood of dead trees of longleaf and slash pine of the southeastern and Gulf States. They are used in many industries for many purposes, the distribution among uses in the United States being shown in table 11.

The naval stores produced in the United States constitute about 68 percent of the world's supply. Industries of the United States consume 55 percent of the turpentine and about 48 percent of the rosin leaving a large balance of both for export.

Table 12 shows the production of naval stores from gum (from the living tree) and from wood (stumps and heartwood) for the period 1910 to 1929, inclusive.

The requirements of industry and commerce have, until the years 1930 to 1932, when the depression has upset markets the world over, taken the total annual production without more than temporary accumulation of stocks in the primary concentration ports. While the carry-over at primary ports for the past three seasons has been and still is a serious burden on the producers of naval stores, there is small reason to doubt the orderly absorption of these surpluses when general economic conditions improve.

The relative proportion of gum naval stores and wood naval stores depends very much upon available timber for gum production.

TABLE 11.—*Percentage distribution of total turpentine and rosin consumption in various manufactures in the United States as of 1928* [1]

Industry	Turpentine	Rosin	Industry	Turpentine	Rosin
	Percent	*Percent*		*Percent*	*Percent*
Paper and paper size	0. 1	36. 0	Matches and woodenware	--------	0. 2
Paint and varnish	80. 4	29. 3	Oils and greases	0. 9	(3)
Soap	(2)	16. 9	Shipyard supplies	1. 3	. 2
Rosin oil, greases, and printing ink	. 2	5. 9	Vehicles	2. 9	. 1
Linoleum, oilcloth, and roofing	(2)	5. 2	Shoe polish and leather dressing	10. 9	. 2
Sealing wax and insulation	1. 2	3. 2	Miscellaneous	. 8	. 4
Foundry supplies	. 3	1. 7			
Pharmaceuticals and chemicals	1. 0	. 7	Total	100. 0	100. 0

[1] From Gamble's International Naval Stores Year Book, 1930–31.
[2] Less than 1/20 of 1 percent.
[3] Included with rosin oil.

TABLE 12.—*Naval stores production in the United States, 1910–29* [1]

Year [2]	Turpentine			Rosin [3]		
	Gum	Wood	Total	Gum	Wood	Total
	Thousand gallons	*Thousand gallons*	*Thousand gallons*	*Thousand barrels*	*Thousand barrels*	*Thousand barrels*
1910	29, 750	750	30, 500	1, 970	14	1, 984
1911	31, 900	1, 000	32, 900	2, 125	23	2, 148
1912	34, 000	1, 200	35, 200	2, 267	98	2, 365
1913	32, 000	1, 250	33, 250	2, 132	130	2, 262
1914	27, 000	576	27, 576	1, 706	34	1, 740
1915	23, 500	700	24, 200	1, 565	40	1, 605
1916	26, 750	1, 000	27, 750	1, 782	89	1, 871
1917	23, 700	1, 800	25, 500	1, 531	160	1, 691
1918	17, 050	1, 300	18, 350	1, 115	123	1, 238
1919	18, 300	1, 535	19, 835	1, 237	158	1, 395
1920	24, 450	1, 750	26, 200	1, 577	180	1, 757
1921	24, 378	442	24, 820	1, 662	53	1, 715
1922	22, 395	1, 859	24, 254	1, 500	152	1, 652
1923	27, 175	2, 607	29, 782	1, 790	201	1, 991
1924	26, 072	3, 261	29, 333	1, 721	258	1, 979
1925	23, 922	[4] 3, 123	27, 045	1, 579	289	1, 868
1926	25, 500	3, 983	29, 483	1, 700	365	2, 065
1927	31, 549	4, 333	35, 882	2, 072	409	2, 481
1928	28, 000	4, 323	32, 323	1, 865	432	2, 297
1929	31, 321	4, 802	36, 123	1, 976	447	2, 423

[1] Compiled by Bureau of Chemistry. Includes trade and association estimates.
[2] Crop year beginning Apr. 1.
[3] Quantities given in barrels of 500 pounds.
[4] Incomplete; does not include destructively distilled wood turpentine.

A shortage of timber for production of gum would be offset by increased production of wood naval stores, but a return to gum naval stores could be expected with recovery of timber resources.

Gallons of turpentine and barrels of rosin do not express so directly the equivalent timber requirement as do feet of lumber or cords of pulpwood. Timber requirements for naval stores can be expressed in acres better than in board feet or cords. The acreage would depend upon factors of size or trees and number of trees per acre, which vary from time to time and one locality to another. Based on typical stands at the present time, it would require more than 18 million acres of turpentine orchards to produce annually the 1929 volume of naval stores. This estimate is based upon an average production of 30 units of naval stores to the crop [1] and an average of 10 active cups per acre. Improved turpentining practice and forest management would reduce this figure by increasing the yield per crop and increasing the trees per acre.

Gum naval stores production cannot be maintained without the timber, but timber required does not constitute the forest drain in this case. A tree after being turpentined is available for lumber or other wood products. The loss in volume of wood usable as lumber is represented by the butt of the turpentined tree and is estimated at a half billion board feet measure for naval-stores production as of 1929.

MINOR WOOD PRODUCTS

Variations in the minor wood products shown in table 13, with the exception of shingles and veneer logs, have held within a rather narrow range over the past 30 years. These products not only occupy a relatively small place in total requirements, but with the exceptions noted, give no evidence of consumption trends of special significance.

Shingle production, which dropped 50 percent from 1910 to 1920, showed resistance to further loss thereafter. It is possible that the large volume of residential construction from 1923 to 1928 had something to do with this stability and that for a normal volume of construction a further decline in shingle production might be expected.

Consumption of veneer logs increased rapidly prior to 1910. There was no great change from 1910 to 1920, but consumption practically doubled from 1919 to 1929. This is due undoubtedly to a growing appreciation of the advantages of plywood and the extension of its use into new fields of construction. The prospects are for further increase in the consumption of veneer material, and because this represents an increasing demand for high-grade logs, it has considerable significance in relation to future timber requirements. The ratio of veneer logs to saw timber was roughly 1 to 100 in 1910 and 1 to 30 in 1929.

Table 13 shows little change in quantity of distillation wood consumed. There has been, however, a decline in hardwood consumption balanced by an increase in softwood. The latter is accounted for by increased production of wood turpentine and rosin, which is discussed under naval-stores requirements. Decline in consumption of hardwoods for distillation has been due to the manufacture of the same products by other processes and from other raw materials at costs that could not be met by the average wood-distillation plant.

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[1] A crop is 10,000 cups. A unit consists of 1 cask (50 gallons) of spirits turpentine and 3½ barrels of rosin.

TABLE 13.—*Consumption of wood in minor products, specified years, 1900–29*

[Forest Service in cooperation with the Bureau of the Census]

Year	Poles purchased	Shingles produced	Veneer logs (domestic)	Distillation wood
	Pieces	*Thousands*	*Thousand board feet* [1]	*Cords*
1900		12, 102, 017		
1904		14, 546, 551		1, 049, 503
1905		15, 340, 909	181, 146	676, 739
1906	3, 574, 666	11, 858, 260	329, 186	1, 195, 130
1907	3, 283, 268	11, 824, 475	348, 523	1, 282, 120
1908	3, 249, 154	12, 106, 483	382, 542	977, 844
1909	3, 738, 740	14, 907, 371	435, 981	1, 265, 157
1910	3, 870, 694	12, 976, 362	477, 479	1, 450, 439
1911	3, 418, 020	12, 113, 867	444, 886	1, 221, 359
1912		12, 037, 685		
1914				1, 042, 517
1915	4, 077, 964	8, 459, 378		
1916		9, 371, 333		
1917		8, 696, 513		
1918		5, 690, 182		
1919		9, 192, 704	576, 581	1, 442, 675
1920		6, 938, 854		
1921		6, 843, 187	400, 388	482, 503
1922		8, 131, 242		
1923	3, 060, 794	7, 506, 869	645, 793	1, 370, 120
1924		6, 862, 385		
1925	3, 281, 514	7, 324, 027	720, 865	1, 276, 245
1926		6, 008, 346		
1927	3, 624, 833	6, 443, 868	943, 993	1, 264, 721
1928		5, 603, 690		
1929	4, 556, 895	6, 110, 672	1, 095, 244	1, 308, 323

Year	Cooperage stock					Chestnut tanning extract wood	Excelsior wood
	Tight staves	Tight heads	Slack staves	Slack heads	Hoops		
	Thousand pieces	*Thousand sets*	*Thousand pieces*	*Thousand sets*	*Thousand pieces*	*Tons*	*Cords*
1905	241, 193	12, 959					
1906	267, 827	17, 774	1, 097, 063	129, 555	330, 892		
1907	385, 232	27, 693	1, 175, 977	106, 074	490, 570		
1908	345, 280	20, 515	1, 557, 644	123, 849	336, 484		
1909	379, 231	20, 691	2, 029, 548	140, 234	375, 793	18, 527	
1910	355, 660	26, 074	1, 460, 878	97, 037	295, 712		
1911	357, 198	30, 310	1, 328, 968	106, 407	353, 215		142, 944
1918	286, 401	20, 711	1, 099, 971	60, 751	332, 684		
1919	353, 825	24, 274	1, 121, 324	87, 381	140, 772	32, 526	
1921	255, 047	20, 505	893, 621	66, 747	137, 380		
1923	222, 507	19, 342	893, 682	80, 477	153, 954	139, 107	171, 077
1925	240, 023	23, 052	937, 597	71, 371	149, 167	104, 268	187, 554
1927	324, 127	26, 445	961, 782	59, 337	134, 596		178, 860
1929	357, 293	30, 329	1, 039, 450	72, 591	133, 054	79, 531	170, 604

[1] Log scale.

SUMMARY

As used herein, the term "timber requirements" denotes a measure of use by consumers afforded a reasonable latitude in choice of materials, including wood. Its only tangible measure is volume of past and current consumption.

Future timber requirements cannot be definitely forecast. Sound policy-making, however, demands that they be anticipated as closely as possible. The data for basing such a program must be supplied by past experience, and the factors which have controlled or influenced trends in consumption. It is the long-time trend, rather than consumption under the conditions existing since 1929, which must be the basis on which requirements are set up. This study is intended to furnish needed data rather than to give exact forecasts for the future.

LUMBER

Total lumber consumption declined from a maximum of approximately 45 billion board feet in 1906 to about 34 billion in 1929. The virtual halt in agricultural expansion since 1910 has practically eliminated a market for 4½ billion board feet of lumber annually for construction on new farms. Agricultural depression since 1921 has curtailed farm repairs and replacements to the extent of approximately 5½ billion board feet annually. This latter item of consumption may be restored when the agricultural depression lifts, giving a normal rural lumber consumption of from 10 billion to 11 billion board feet annually.

A large-scale change from single-family dwellings to multifamily housing and the intrusion of other materials in urban residential construction have caused lumber consumption in that category to lag far behind the great increase in urban building, but kept it well ahead of rural consumption. Between 1912 and 1928 there was a relative drop of 25 percent in lumber used in urban residential construction. Urban construction other than residential doubled between 1912 and 1928, but lumber consumption for this purpose remained stationary. Thus 50 percent of a former lumber use has been replaced by other materials.

There is nothing to indicate measurable expansion in the consumption of lumber for factory use or for railroad car construction. On the whole, a decline seems more likely. Lumber used in furniture increased 25 percent between 1912 and 1928 and appears to be holding its own.

After considering all factors, an estimated figure of normal lumber requirements for the Nation as at present lies between 31 and 34 billion board feet. "Normal" requirements are taken to be the volume of consumption that might logically be expected when general economic conditions are such that the Nation is conscious neither of depression nor of unusual prosperity.

Future lumber requirements depend on such factors as the restoration of agricultural prosperity, the effect of the current urban-to-farm movement on rural construction, success in meeting competition of other materials, the extent to which the all-wood house holds its place in urban construction, the rate of population increase (now estimated to cease between 1950 and 1970), and the effect of obsolescence on replacement.

PULPWOOD, PULP, AND PAPER

Paper requirements increased steadily for more than 100 years, until 1929. Whether the decline since then marks a change in the general trend cannot be determined as yet. It is reasonable to expect a saturation point in newsprint, especially in view of a declining rate of population increase, but the consumption of wood for other pulp products appears to have plenty of room to expand, particularly in the fields of fiber-board boxes and insulating materials, and for rayon and other cellulose products. Wood is the favored material for pulp and paper and should be able to hold its place against other raw materials.

The largest field for expansion of our native timber requirements lies in the possibility of substituting domestic production for the half of our consumption which is imported. The possibilities in this direction are greatly enhanced by the prospect of a continued rise in paper requirements. Total pulpwood requirements for the country amounted to nearly 13½ million cords in 1930. Estimates of probable requirements by 1950 vary from 22 million cords to 30 million cords.

FUEL WOOD

Our annual consumption of wood as fuel has shown a considerable decline from earlier estimates of more than 100,000,000 cords to a present estimate of about 61,000,000 cords. The decline has occurred largely in cities and towns. Wood has remained and is likely to remain the chief fuel in rural sections, and requirements may now be approaching a minimum for that purpose.

OTHER TIMBER PRODUCTS

Trends in minor and miscellaneous timber products do not definitely indicate any great change in total requirements from those of 1929. The most important recent increase has occurred in consumption of logs for veneer and plywood.

THE GENERAL OUTLOOK

Obviously there have been and still are so many factors at work influencing trends in the consumption of forest products that no generalization as to the future can be validated. It is impossible to reduce the net effect of opposing factors of declining and increasing use to exact estimates. However, for the consideration of both the consumer who would like to use wood and the owner of forest land who seeks a profitable outlet for his timber crop, it is well to revert to the introductory statement wherein it is pointed out that the consumption of wood is, in general, likely to vary with the abundance, suitability, and cheapness of its supply.

Mention must also be made of the fact that manufacturing and merchandising of lumber and other forest products, with the exception of paper, have changed little during the past 30 years during which time science and invention have wrought momentous changes in nearly every other field of industry. Hence, it is reasonable to feel that modern scientific methods applied to promoting the use of forest products, whether in present forms or something entirely different, would increase consumption much as in the case of other materials. Measures by which this can and may be accomplished are discussed in the section, "Enlarging the Consumption of Forest Products."

And, finally the timber requirements of a nation are measured as well by the need for industry as by the need for the products of industry. The conversion of timber into tables and chairs, let us say, is the basis for a large industry, employing thousands of wage earners to satisfy the market for tables and chairs. But it is not only our need for tables and chairs, but the employment of labor to manufacture them, that measures the importance of the industry and therefore of the raw materials necessary to maintain the industry.

If we did not need tables and chairs, we should need to find other uses for the timber in order to support an equivalent industry. That should be our objective in any case, since timberlands constitute one of our major resources, and national welfare depends upon the use we make of our resources. It would be unfortunate if requirements were to be accepted as the minimum amount of timber necessary to maintain a present limited concept of industry, neglecting requirements for expansion of forest industry as a prime factor in land use and employment of labor.

TRENDS IN WORLD WOOD CONSUMPTION

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INTRODUCTION

A study of the prospective timber requirements of the United States would be incomplete without consideration of the trends in world consumption. The international trade in wood is large. Countries which have inadequate supplies of the wanted kinds of wood supplement domestic production with imports from countries with a surplus. Countries with more timber than they need at home look to foreign markets to dispose of it. The trends in wood requirements of both exporting and importing countries, therefore, have an important bearing on the future ability of the United States to meet its timber needs through importation, or to dispose of a possible surplus through sale to foreign consumers.

USE OF WOOD PRIOR TO INDUSTRIAL ERA

Wood is a perishable material. Therefore, few wooden remnants have reached us from prehistoric peoples. An indication of the part that wood played in the life of prehistoric man may be learned, however, through the study of the present day primitive races of Africa, South America, Australia, and the islands of the Pacific. From the study of these races, particularly those which inhabit forested regions, we find that wood provides an almost indispensable source of fuel, weapons, implements, utensils, and other objects of everyday life.

We are in a better position to learn the extent to which wood was used by the ancient historic peoples of the Mediterranean region and in the valleys of the Tigris and the Euphrates. Except for the mountains, these regions were poorly forested. Yet wood was extensively used, both in architecture and in naval construction, as well as in everyday life. The Iliad and the Odyssey reflect the manner of living of the ancient Greeks in the early periods of their culture. In these poems we find descriptions of how and for what purpose and what kinds of woods were used. Similarly, the classical writers describe the use of wood in ancient Rome. There, as in Greece, wood was particularly essential for naval construction.

In the Middle Ages, European culture developed under entirely different geographic conditions than in antiquity. The centers of culture shifted from the Mediterranean region to central and western Europe. The Mediterranean lands were poorly forested, but central and western Europe during that period was typically a forested region. The forests played an important part in the economic life of the people of the Middle Ages, not only as a source of fuel and raw materials, but also as an inimical environment which they had to overcome in their struggle to make room for cultivation and pasturage. By the end of the fourteenth century, man had conquered the forests. By the fifteenth century, the conquest had gone so far that in some parts of Germany, and elsewhere, there began to be complaints of the exhaustion of forests and demands that excessive clearing be stopped.

Between the thirteenth and the fifteenth centuries wood ceased to be purely a local commodity in Europe, and timber began to be an article of international trade, transported in rafts along the rivers. Along with the development of the timber trade, there grew up the sawmill industry. The first sawmills operated by water power appeared in France in the thirteenth century, although whipsawing by hand remained the prevailing method of sawing lumber for several centuries. Wood was the dominant material for ordinary house construction during the period between the thirteenth and the seventeenth centuries.

As the cities increased in number and grew in size, the consumption of wood, the only source of fuel of that time, became very great. Supplying such cities as Paris, Vienna, and London with firewood became a vast enterprise. The Thames, even as late as the eighteenth century, served as a main channel for supplying London with firewood. Beginning as early as the fourteenth century, first in Germany and later in Sweden and England, there was a notable growth of the metallurgical industry, which required great quantities of charcoal and firewood. The glass and pottery industries also came to the front. The growth of these industries, located largely in the forests, together with the growing consumption by the cities, brought on a shortage of fuel wood. In the eighteenth century there arose throughout western Europe an acute fuel crisis. The shortage of wood led even to the curtailment of the metallurgical industry. Laws were passed, for instance, prohibiting construction of metallurgical plants nearer than 22 miles from London. In cities where there was a shortage of fuel wood for bakeries there arose a demand in the name of humanity to close the metallurgical plants, because it was reasoned that it was better to leave people without iron than without bread. The shortage of firewood was occasioned by the exhaustion of the nearby forests or those within hauling distance of the rivers. Large supplies of timber remained, but owing to the difficulty of transportation these were as good as nonexistent.

Meanwhile, the demand for timber for many other purposes had been growing by leaps and bounds. A very important use was for ship construction. Between the sixteenth and the eighteenth centuries was a period of rapid growth of the navies and merchant marine of Spain, France, Holland, England, and other countries. In 1577 England had only 135 merchant vessels above 100 tons capacity. In 1701 her merchant marine comprised 3,281 vessels, with a total capacity of 261,222 tons, and in 1788 she had 9,360 vessels, with a capacity of more than a million tons.

The French Navy grew from 30 vessels in 1661 to 244 at the death of Colbert in 1683. The cost of building one large naval vessel in the eighteenth century was around $18,500, of which more than $5,800 was for timber. According to French records of the eighteenth century, the construction of one vessel armed with 100 to 200 cannon required about 4,000 logs of best quality. According to other records, 1,000 cubic feet of wood was required for every cannon installed on the ship, and 35 cubic feet for every ton of carrying capacity of the merchant marine. Until the second half of the nineteenth century, the navy and the merchant marine were built entirely of wood.

In time of war many vessels were sunk or damaged and the demand for wood for naval construction greatly increased. During the Napoleonic wars the needs of the French navy amounted to more than 9 million cubic feet a year. As late as 1846 the total volume of timber used by the French fleet amounted to 23 million cubic feet. Naval construction usually demanded timber of large size. Not every country possessed a sufficient supply of such timber. Naval timber became, therefore, an important item of international trade during the seventeenth and eighteenth centuries. The Baltic countries furnished large quantities, as did also the virgin forests of the American Colonies. As early as 1754 South and North Carolina exported 1,876,330 boards, 210,000 ship timbers, and 3,042,000 feet of other wood for naval construction.

At the beginning of the nineteenth century many parts of Europe still had large forests and preserved to a considerable extent the stamp of wooden culture. Sombart thus describes the condition which existed in Germany a hundred years ago. "A traveler of that time entered into the shade of a forest more often than now. Century-old giants were still standing. The forest played an entirely different role in the life of the people of that period than today. The material culture of the northern countries was rooted in the forest. The traveler encountered everywhere in the forest poor poeple who collected branchwood, berries, leaf litter for bedding their stables, and other forest by-products. The swine of the poor searched for acorns in the forest for food. The cows and goats browsed on the grass in the openings and on the edge of the forest. From the forest man obtained raw material for the manufacture of all kinds of articles which he sold at fairs and market places. The very culture of our ancestors was wooden. Fire was obtained from wood, from wood were built houses and bridges; from wood were made innumerable articles of everyday life, articles which we know only by name."[1] Such were the conditions in Germany a hundred years ago.

USE OF WOOD IN MODERN TIMES

The industrial revolution, beginning toward the end of the eighteenth century, brought mankind to the age of coal and iron, steam and electricity. Coal gradually took the place of wood fuel, charcoal, and peat. Iron and steel crowded out wood to a large extent from the construction of ships and bridges, and in the manufacture of implements of every kind. It would seem that the replacement of wood with coal and iron would have ended or greatly reduced the demand for wood. It would seem that the consumption of wood and the destruction of forests in the age of coal and iron should have become much less than in the eighteenth century.

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[1] Sombart, V. Der moderne Kapitalismus. I. 1922.

It is true that this replacement of wood with coal at times led to a restricted use of wood and caused difficulties in finding a market for it. Paris may serve as an illustration of the changes that took place in the use of fuel, since in France even today firewood is extensively used in heating residences. In 1815 the 670,000 inhabitants of Paris consumed almost 42.5 million cubic feet of firewood, or around 63 cubic feet per inhabitant. By 1865 the population had increased to 1,668,000 but the consumption of firewood was only 26.7 million cubic feet, or 16 cubic feet per inhabitant. In 1900 the consumption of firewood amounted to 19.5 million cubic feet, or a little over 7 cubic feet per inhabitant. The per capita consumption of charcoal decreased from 7.8 bushels in 1856 to 3.6 bushels in 1896 and 2.8 bushels in 1900. The consumption of coal, on the other hand, was many times larger at the end of the century than at the beginning.

The loss to forest owners resulting from this drop in the use of wood was further aggravated by the reduction in the consumption of fuel wood by metallurgical plants. A similar situation developed in many other centers of wood consumption in Europe. Wood prices fell so low and the maintenance of forests became so unprofitable that in many instances attempts were made to clear the forests and turn them into pastures.

All signs apparently pointed to a permanent decrease in the use of wood. But this was not to be. The new era of capitalism was characterized by a period of industrial expansion which gradually extended to a large part of the world, continued throughout the nineteenth century, and reached its fullest development in the period just before the World War. Agriculture, freed from the bonds of the feudal system and stimulated by the industrial expansion, also entered upon a new phase of development in western Europe. The industrial expansion was accompanied by building of railroads and other means of transportation, development of mines, construction of new factories and houses, and a general rise in the standard of living of the masses. Chemistry opened new fields of use for cellulose, for which wood was the best source. Wider education of the masses brought greater use of paper for books and newspapers. Increased trade required boxes and containers of various sorts. With the improvement of the lot of the industrial worker and the peasant, there came a demand for better houses, more furniture, and wooden articles for household use.

As a result of this wave of industrial expansion, wood regained its prominent place in the economic life of the people, although it was used in different forms than before. The industrial revolution of the nineteenth century, which at first threatened to destroy the markets for wood, in the end stimulated the use of wood in the most unexpected industrial enterprises and thus widened its markets. This demand was so great that some of the industrial countries were unable to meet it from their own timber supplies. They were forced to tap the resources of other countries which possessed a surplus of forest wealth. This brought about a world trade in timber of a magnitude not dreamed of in the period before the industrial revolution.

IS WORLD CONSUMPTION DECREASING?

The United States was an especially lavish consumer of wood during the nineteenth century. The population was doubling every 30 years. Farms, towns, and cities were multiplying at a phenomenal rate. A network of railroads was being extended from the Atlantic Ocean to the Pacific, and from Canada to the Gulf of Mexico. Industries of all kinds were growing at a rate which has probably never been equaled anywhere else in the world. A wealth of virgin timber, excellently adapted to a great variety of uses, was ready at hand or easily reached by railroads and waterways, and was practically free for the taking. No wonder, then, that the per capita consumption of wood in America surpassed that of most of the other industrial nations, which no longer had extensive virgin forests.

The consumption of sawed lumber and probably the aggregate consumption of wood in all forms reached a peak about 1906 or 1907. About that time the rate of population growth began to slow up, and within a few years the number of farms and the mileage of railroads reached their peaks, while at the same time the tendency to concentrate people and industries in multistoried buildings in the cities called for the use of more steel and concrete and less wood in construction. Both the per capita and the total wood consumption began to fall off, and the decline has continued, with some interruptions, ever since. The consumption of lumber has declined almost precipitously since 1929.

This decreasing rate of consumption in the United States during the last 25 years, coupled with the decreasing consumption in practically all countries since 1929, has given rise to the widespread belief that the trend of world timber consumption is inevitably downward. Not only the forest owners, but also those responsible for formulating public forest policies are questioning whether there will be any demand for timber in the future. As a result of present conditions, there has been generated in this country a pessimistic psychology not unlike that which prevailed in Europe toward the end of the eighteenth century as regards the future possibilities of the use of wood. There is a feeling that wood use is at the end of an economic epoch, and that from now on wood is to play a progressively smaller part in human civilization.

CONSUMPTION TRENDS

Examination of the facts regarding world timber consumption is therefore of interest. Statistics are not available for every country, but a study of the trends in some of the representative consuming countries will give sufficient indication of what may be expected.

GREAT BRITAIN

In Great Britain,[2] approximately 95 percent of all the wood consumed is imported. For many years domestic production has furnished only an insignificant portion of the total quantity consumed. The growth or decline of imports, therefore, reflects closely the trend in consumption.

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[2] Information supplied by Arthur C. Ringland, principal forestry specialist, based upon records of the British Forestry Commission and data supplied by Mr. Fraser Story, of the commission.

TABLE 1.—*Average annual imports of unmanufactured timber, other than pulpwood, into Great Britain*

Period	Hewn and sawn softwoods		Hewn and sawn hardwoods		Pit props		All classes	
	Total	Per capita	Total	Per capita	Total	Per capita	Total	Per capita
	Million cubic feet	*Cubic feet*	*Million cubic feet*	*Cubic feet*	*Million cubic feet*	*Cubic feet*	*Million cubic feet*	*Cubic feet*
1843–52							93.4	3.4
1853–62							136.0	4.8
1863–72							207.8	6.8
1873–82							294.0	8.8
1883–92							331.2	9.0
1893–1902							439.8	11.1
1903–08							479.8	11.0
1909–13	329.5	7.3	33.5	0.7	147.2	3.2	510.2	11.2
1914–18	175.6	3.8	18.4	.4	83.7	1.8	277.7	6.0
1919–23	228.7	4.9	23.5	.5	112.4	2.4	364.6	7.8
1924–25	324.2	7.4	40.3	.9	137.7	3.2	502.2	11.5
1926	294.8	6.7	35.8	.8	79.1	1.9	409.7	9.4
1927–30	328.9	7.4	42.9	1.0	136.7	3.1	508.5	11.5
1931	279.4	6.2	32.3	.8	94.9	2.1	406.6	9.1

NOTE.—Volumes are not converted into equivalents of standing timber. Ireland not included after 1923.

Statistics of timber imports are available for the period 1843 to 1909 as to total volume and from 1909 to the present by classes of material. During the 50 years from 1843 to 1893 Great Britain's import of timber (including all classes except pulpwood) increased fivefold, and the per capita imports increased three times from 3.4 cubic feet to 11.1 cubic feet. (See table 1.) The last three decades of this period were characterized by a rapid increase in population growth. From 1893 to 1914 imports continued at an average level of about 11 cubic feet per capita. They decreased almost one half during the war decade from 1914 to 1923. The year 1924 marks the resumption of normal conditions. From that year to 1930, excepting 1926, the year of the general strike, imports regained their pre-war level, and averaged 11.5 cubic feet per capita, although during the period there was a sharp decline in the rate of population increase. In 1931 there was a sharp drop to 9.1 cubic feet, a direct reflection of the generally prevailing depression.

For almost 40 years, then, except for the decade including and immediately following the World War, imports of unmanufactured timber other than pulpwood have maintained a level of slightly more than 11 cubic feet per capita.

The consumption of pit props shows a tendency to decline slightly, but not enough to affect the general average. The import of mining timbers for the period 1901–5 averaged more than 106 million cubic feet; during the period 1909–13 it was more than 147 million cubic feet; and during the period 1924–30, not including 1926, the average dropped to 137 million cubic feet. In 1931 there was a sharp drop, as with all other classes of timber.

The consumption of pulpwood has increased greatly since the war. Imports during 1909–13 averaged 59.3 million cubic feet. In 1924 the import was 84.7 million and in 1930 it was 105.7 million cubic feet.

A census of home production has been taken only twice, in 1924 and in 1930. In 1924 the home production of all classes of wood was

56 million cubic feet (in terms of standing timber); in 1930 it was 48.1 million cubic feet.

In terms of the equivalent in standing timber the total consumption of all kinds of wood was 1,032 million cubic feet, or 23.8 cubic feet per capita in 1924, and 1,035 million cubic feet, or 23.2 cubic feet per capita in 1930. Average consumption for the period 1909–13 is estimated at 992 million cubic feet, or 21.9 cubic feet per capita. (See table 2.) The per capita increase in 1924 and 1930 is explained by the increase in pulpwood. According to another estimate, the per capita consumption in 1928–29 was the same as in 1913, or 20.8 cubic feet.

TABLE 2.—*Consumption of timber in Great Britain (equivalent in standing timber)*

Year	Imported			Home production	Total	Per capita
	Hewn and sawn		Pulpwood			
	Softwoods	Hardwoods				
	Million cubic feet	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Cubic feet*
1909–13 (average)	810.4	72.4	59.3	50.0	992.1	21.9
1924	806.8	84.1	84.7	56.0	1,031.6	23.8
1930	789.9	91.5	105.7	48.1	1,035.2	23.2

The rate of population increase is now only one third of the rate between 1882 and 1908. The population is leveling out and the industrial expansion of the past may not be continued in the immediate future. The resumption of normal purchasing power is sure to create a demand for repairs and new buildings now deferred. An increased use of wood pulp may be expected. British forestry officials state that, considering the needs of the country as a whole, they look for no decrease insofar as future wants can now be foreseen. Home production is expected to remain relatively unimportant, and imports will probably continue at about the same level as in recent normal years.

GERMANY

In Germany the per capita consumption of timber doubled between 1870 and 1913, and the per capita consumption of paper during the same period increased three and one half times. The peak of per capita consumption of all timber, including firewood, was reached between 1907 and 1913, when it amounted to 37.8 cubic feet in terms of round timber. For the period 1925–28 the average consumption was about 10 percent less, or 34.2 cubic feet. This decrease was due mostly to reduced use of firewood, which decreased from 16.1 cubic feet per capita in 1907–13 to 13.8 cubic feet in 1925–28. The total consumption, in terms of round timber, rose from 2,021 million cubic feet in 1900 to 2,503 million cubic feet in 1913. In 1925–28 the average consumption was only 2,180 million cubic feet, but the population was approximately 3 million less than in 1913.

The net imports of timber in 1913 were almost five times larger than in 1870, and in 1927 they were larger than in 1913. Germany imports chiefly round timber. With the present reduced consumption and low prices, the large imports of round timber, which include pulpwood, from Austria, Poland, Czechoslovakia, and Russia are now threatening the profitableness of German forests. The forest owners are demanding that the government curtail importation by increasing the tariff and requiring the use of domestic wood. Since, however, the normal needs of Germany are greater than can be covered by the domestic supplies, imports will undoubtedly continue.

ITALY

In Italy the per capita consumption of wood was practically the same (21.6 cubic feet) in 1924–25 as it was in 1909–13 (21.8 cubic feet). Although both imports and domestic production increased after the war, this was accounted for by the addition of new territory and increased population.

BELGIUM AND NETHERLANDS

Imports of timber into Belgium after the war were considerably larger than before. The total consumption of fuel wood, which is normally very small, remained at a fairly constant level, but per capita consumption of other timber decreased by about 8 percent between 1913 and 1929. The consumption of wood in all forms, expressed in terms of standing timber, was 32.5 cubic feet per capita in 1913 and 30.0 cubic feet in 1928–29.

In the Netherlands the trend has been about the same, although the rate of consumption is slightly lower. In 1913 it amounted to 23.3 cubic feet per capita, and in 1928–29 to 21.5 cubic feet.

SWITZERLAND

In Switzerland, on the other hand, there has been a considerable increase in consumption of both timber and fuel wood since the war. Almost half of the wood consumed in Switzerland is for fuel. Per capita consumption of all classes, in terms of standing timber, was 31.1 cubic feet in 1913 and 36.4 cubic feet in 1928–29.

DENMARK

In Denmark, both total and per capita consumption of wood increased between 1900 and 1913. After a small decrease during the World War, consumption again rose to almost the level of 1913. Although the rate of use per capita was slightly lower, the increase in population resulted in a greater total consumption. The figure for 1930 is larger than it would have been but for an abnormal amount of building in that year. Table 3 shows the consumption, in terms of standing timber, in different years between 1900 and 1930.

TABLE 3.—*Timber consumption in Denmark, 1900–1930* [1]

Year	Total consumption	Per capita consumption
	Million cubic feet	*Cubic feet*
1900	79.0	32.5
1905	86.9	33.9
1910	96.8	35.3
1913	118.2	41.7
1920	99.3	32.1
1925	119.7	35.0
1930	151.7	42.7

[1] Based on data obtained by Arthur C. Ringland from Prof. A. Howard Grøn, Copenhagen.

FRANCE

Although timber consumption in France is low in comparison with some other countries, it has been increasing gradually. French forests supply chiefly fuel wood, mine timbers, and other low-grade material, and large quantities of construction timber are imported. During the war and subsequently there has been considerable overcutting in French forests. The normal annual consumption of timber, not including firewood, is estimated to have been 353 million cubic feet in 1912, 424 million in 1919, and 565 million in 1930.[3]

RUSSIA

Russia, because of her vast forest resources, is of particular interest in tracing the changes in the use of wood.

Pre-war estimates of wood consumption in Russia, including Finland and the Baltic Provinces, placed it at about 353 cubic feet per capita for the northern part of the country and about 17.5 cubic feet for the south. The average for European and Asiatic Russia together was probably about 60 or 65 cubic feet.

Immediately after the close of the war and during the Revolution, Russian economic life came practically to a standstill. Timber export completely stopped, sawmills remained idle, and timber cutting as an organized enterprise practically ceased. Very little timber was cut except for firewood to heat the houses and maintain the feeble railroad transportation. Cutting was concentrated in the forests near the villages and for distances of 20 to 30 miles back from the railroads and the rivers. Statistics of wood consumption during this period are not available, but it must have been greatly reduced. According to some estimates, it averaged only one fourth of the pre-war consumption, or about 15 cubic feet per capita.

Beginning with 1922, there was a gradual revival of forest industries and an increase in wood consumption. Since the Five-year Plan went into effect the needs of the country for wood have had to be more definitely determined and plans developed for meeting these needs. According to the official statistics,[4] the actual cut from Russian forests during the period 1924–30 was as follows:

Year	Total cut	Per capita	Year	Total cut	Per capita
	Cubic feet	*Cubic feet*		*Cubic feet*	*Cubic feet*
1924–25	3,800,000,000	24.0	1927–28	5,300,000,000	34.0
1925–26	5,300,000,000	33.7	1928–29	6,400,000,000	41.0
1926–27	4,900,000,000	31.4	1929–30	8,500,000,000	54.4

Until recently, firewood constituted about half of the total cut in Russia. Although the plans call for an increasing cut of saw timber, the proportion of firewood is to be gradually reduced. The total cut of all classes of wood increased from 24 cubic feet per capita in 1925 to 54 cubic feet in 1930, or 125 percent. As only about 5 percent of the cut is exported, the consumption and cut of wood may be considered as practically identical. The 1930 consumption was still slightly below the pre-war average.

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[3] Hervet, Gilbert. La question forestière depuis la guerre. Dijon, 1931.

[4] Buchholz, E. Zustand und Entwicklungstendenzen der russischen Wald- und Holzwirtschaft. Eberswalde, 1932.

The estimated requirements provided for in the plan, beginning with 1930–31, are as follows:

Year	Saw timber	Firewood	Total
	Cubic feet	*Cubic feet*	*Cubic feet*
1930–31	6,000,000,000	3,000,000,000	9,000,000,000
1931–32	7,400,000,000	3,200,000,000	10.600,000,000
1932–33	8,800,000,000	3.600,000,000	12.400,000,000
1933–34	10,200,000,000	4.000,000,000	14.200,000,000
1934–35	11,500,000,000	4.400,000,000	15.900,000,000
1935–36	12,900,000.000	4.800,000,000	17.700,000,000
1936–37	14,300,000,000	5.100,000,000	19.400,000.000
1937–38	15,600,000,000	5.600,000,000	21.200,000,000

Revised estimates provide for an even larger cut. There may be some question as to whether timber production can be expanded exactly according to schedule, but there can be little doubt that Russia will consume larger and larger quantities of wood during the next few decades, if industrialization proceeds along the lines that are contemplated. This will parallel the history of timber consumption during the industrial development of other countries.

If the estimates for the next 5 years should be realized, the consumption of wood in Russia by 1938 would be more than five times that in 1924. The total cut planned for 1933–34 is close to the predepression total cut in the United States, and considerably larger than the aggregate consumption of all European countries outside of Russia. Even with this increase in output, Russia, according to some economists, would still fall short of meeting her domestic needs for saw timber in 1935 by 500 million cubic feet, and in 1940 by nearly a billion cubic feet.

CENTRAL, NORTHERN, AND WESTERN EUROPE AS A WHOLE

A recent study of wood consumption in Europe,[5] excepting the Mediterranean and Danubian States, gives the following comparative figures for 1913 and 1928–29 (table 4).

TABLE 4.—*Per capita annual timber consumption in European countries, 1913 and 1928–29 (in equivalents of standing timber)*

Country	Saw timber [1]		All timber	
	1913	1928–29	1913	1928–29
	Cubic feet	*Cubic feet*	*Cubic feet*	*Cubic feet*
Finland [2]	48.0	102.4	227.4	245.8
Latvia [2]	35.3	51.2	70.6	99.6
Estonia	35.3	38.1	70.6	98.2
Switzerland	16.2	19.4	31.1	36.4
Czechoslovakia	14.1	18.4	26.5	28.6
France	10.6	11.3	26.1	26.8
Poland	10.2	10.2	20.8	21.9
Great Britain	20.1	20.5	20.8	20.8
Sweden	72.4	64.6	185.0	162.8
Norway	55.1	37.4	116.5	71.3
Austria	16.6	18.0	40.6	37.1
Denmark	30.0	24.7	38.8	32.5
Germany	21.9	20.8	37.4	34.6
Lithuania [3]	17.7	8.5	35.3	16.6
Belgium	25.8	23.7	32.5	30.0
Netherlands	20.8	19.4	23.3	21.5

[1] Saw timber includes all classes of wood except firewood.

[2] Large apparent increase in saw-timber consumption in Finland explained by better statistics in 1928–29. Part of increase in Latvia also results from better statistics.

[3] Abnormally low consumption in 1928–29, due to disturbed conditions.

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[5] Information supplied by Arthur C. Ringland, based on studies by Dr. Egon Glesinger.

The total timber consumption (not including firewood) of the seven importing countries (Great Britain, France, Germany, Belgium, Netherlands, Denmark, and Switzerland) increased by 1.7 percent between 1913 and 1928–29, or somewhat more slowly than the population. Consumption of firewood in these countries decreased by 5.7 percent in the same interval. For the three Scandinavian countries (Norway, Sweden, and Finland) timber consumption apparently increased 20.8 percent and that of firewood decreased 13.8 percent. Part of the change may have been due to the better statistics for Finland in 1928–29. For the three central countries (Poland, Czechoslovakia, and Austria) timber consumption also increased by 20.4 percent, and firewood consumption increased by 0.7 percent. Although the consumption was perhaps a little above what has been considered normal for these countries, it is expected to increase still more during the next few years. In the Baltic countries (Latvia, Estonia, and Lithuania) timber consumption decreased by 15.1 percent and firewood by 4.7 percent. The population also decreased in these countries, and consumption in Lithuania, at least, was abnormally low in 1928–29 because of upset economic conditions.

The 16 countries consumed practically the same total quantity of timber and firewood in the 2 years, or approximately 8,640 million cubic feet. The per capita consumption decreased from 36.4 to 35.3 cubic feet. This decrease was due to a lower consumption of firewood. Total firewood used decreased from 3,970 million to 3,670 million cubic feet, and the per capita consumption from 16.6 to 14.8 cubic feet. Per capita consumption of timber other than firewood increased from 19.8 to 20.5 cubic feet.

TRENDS IN WORLD TRADE

Statistics of world trade afford another measure of the demand for wood. In attempting to determine the trend in world trade, it is necessary to distinguish four periods: (1) The pre-war period; (2) the war period; (3) the postwar period between 1919 and 1929; and (4) the period of economic depression since 1929. It is evident that the war period and the period of depression, being abnormal, do not lend themselves to a determination of trends. To a considerable extent this is also true of the reconstruction period from 1919 to 1929.

PRE-WAR PERIOD

Reliable statistics of world trade in wood are available only since about 1880. Even the figures for the period from 1880 to 1913 show very convincingly the growing importance of wood in world trade prior to the World War.

The aggregate export of wood, excluding pulpwood and cellulose, from the seven most important timber-producing countries more than doubled during the period between 1880 and 1913, showing by 5-year periods an uninterrupted growth (table 5). Only one of these countries (Norway) exported less timber at the end of the period than at the beginning. The exports of pulpwood and cellulose increased even more rapidly.

TABLE 5.—*Average annual timber exports from principal exporting countries, 1881–1913, not including pulpwood and wood pulp*

[In million cubic feet]

Period	Russia	Austria-Hungary	United States	Finland	Sweden	Norway	Canada	Total
1881–85	118.6	127.0	58.0	91.8	161.7	76.9	86.8	720.8
1886–90	137.2	131.9	72.2	74.2	183.5	65.6	62.3	726.9
1891–95	164.8	135.9	83.9	102.4	210.0	63.0	70.3	830.3
1896–1900	182.5	194.5	129.0	144.7	240.9	69.8	74.8	1,036.2
1901–05	242.4	225.0	175.7	201.2	238.3	68.0	90.0	1,240.6
1906–10	379.3	212.5	203.2	204.9	213.8	56.6	104.6	1,374.9
1911–13	428.0	206.0	253.9	247.1	226.0	40.6	110.3	1,511.9

WAR PERIOD

The war period disrupted the old channels of world timber trade. The total annual exports from the seven principal exporting countries during the 5-year war period, 1914–18, dropped to about 40 percent of the pre-war exports and the participation of the different countries materially changed, as shown in table 6.

TABLE 6.—*Timber exports from principal exporting countries before and during the World War, not including pulpwood and cellulose*

[In million cubic feet]

Period	Russia	Austria-Hungary	United States	Finland	Sweden	Norway	Canada	Total
1911–13, average	428.0	206.0	253.9	247.1	226.0	40.6	110.3	1,511.9
1914	273.0	(1)	256.0	173.0	115.1	32.5	113.3	962.9
1915	48.2	(1)	114.6	76.5	172.7	47.7	126.6	586.3
1916	55.3	(1)	120.1	133.3	186.6	48.3	142.8	686.4
1917	30.9	(1)	108.5	64.8	124.0	34.2	144.4	506.8
1918	----------	(1)	102.1	16.5	116.8	25.8	67.4	328.6
1914–18, average	81.5	(1)	140.3	92.8	143.0	37.7	118.9	614.2

[1] Exports from Austria-Hungary were practically negligible during the war.

POST-WAR PERIOD TO 1929

After the war, with the revival of normal economic activity, world trade in timber rapidly expanded. Building construction in most European countries was naturally at a standstill during the war. The wood which was cut went chiefly into temporary buildings, temporary railroads, military equipment, and other transitory uses. At the time of the armistice there was a great stored-up demand, not only for actual reconstruction in the war-torn countries, but for normal construction which had been held up by the war. Furthermore, some of the European countries, cut off during the war from the outside sources of supplies, had made heavy inroads into their own limited forests and many forests in the war zones had been destroyed by shell fire. There was, therefore, every reason to expect at the end of the war a rapid expansion in timber trade. As a matter of fact, such an expansion materialized. The new countries which came into existence through the peace treaties began feverishly to convert their forests into cash. The Scandinavian countries, which had accumulated a surplus of lumber during the war, began to ship large quantities and both Canada and the United States increased their exports. With the exception of the depression year 1921, there was a rapid increase in wood exports from the close of the war until the end of 1929. By 1924 the exports had exceeded pre-war volume, and during the next few years, particularly 1927, 1928, and 1929, they attained new high levels.

It is difficult to compare the wood exports of the pre-war period with those from the same countries in the post-war period because some of the largest exporting nations were split up into smaller political units. Czechoslovakia, Hungary, part of Rumania, part of Poland, part of Italy, and part of Yugoslavia were split off from Austria-Hungary; the Baltic provinces, part of Rumania, and part of Poland from Russia; and part of Poland from Germany. As a result of the establishment of new frontiers, some timber shipments that would have constituted internal trade before the war now appear as exports. The exports of sawn softwood lumber from the principal exporting countries before and after the war are shown in table 7.[6]

TABLE 7.—*Exports of sawn softwood lumber from principal exporting countries*

[In million board feet]

Country	Year				
	1880	1900	1913	Average 1925–29	Average 1930–31
Norway	528	465	303	231	166
Sweden	1, 255	1, 994	2, 071	1, 937	1, 624
Finland	608	925	1, 546	2, 108	1, 542
Russia	396	1, 267	2, 881	1, 020	1, 881
Latvia				308	318
Lithuania				28	29
Estonia				130	80
Poland				902	558
Rumania	63	42	129	843	586
Austria	380	881	1, 075	777	563
Czechoslovakia				361	168
Yugoslavia				476	418
Canada	1, 529	1, 689	1, 428	2, 094	1, 126
United States	295	1, 594	2, 691	2, 557	1, 632
Total	5, 054	8, 857	12, 124	13, 772	10, 691

NOTE.—Before 1918, Latvia, Lithuania, and Estonia were included in Russia; Poland was included in Russia, Germany, and Austria-Hungary; parts of present Rumania were in Russia and Austria-Hungary; Czechoslovakia and most of Yugoslavia were in Austria-Hungary. From 400 to 600 million board feet of the post-war totals represent a statistical rather than an actual increase in exports, resulting from the establishment of new frontiers.

PERIOD OF ECONOMIC DEPRESSION

Since 1930 the world timber trade has become utterly disorganized. Consumption of timber, both in exporting and in importing countries, has declined greatly. For instance, the imports of sawn timber into England fell from 322 million cubic feet in 1929 to 269 million cubic feet in 1931. In Germany import of coniferous timber dropped from 560 million cubic feet in 1928 to 201 million cubic feet in 1931. In Italy imports of sawn, round, and square timber, which amounted to 119 million cubic feet in 1927, shrank to 81 million cubic feet in 1931.

This, of course, meant a contraction in exports. Finland, for instance, which in 1927 exported 210 million cubic feet of lumber, exported only 129 million cubic feet in 1931, an amount less than before the war. Swedish lumber exports, which in 1929 reached a high level of 195 million cubic feet, shrank to 120 million in 1931, also below the 1913 figure. Polish exports fell from 140 million cubic feet in 1927 to 70 million in 1931. With the exception of Russia, the principal other exporting countries show a similar downward tendency.

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[6] Based on T. Streyffert, Sawn woodgoods. Index 7:62–85 (published by Svenska Handelsbanken, Stockholm, March 1932).

The power of consumption decreased more rapidly than the supplies available. This led to a collapse of prices, which in many instances are now below the pre-war level. This can hardly be more than a temporary condition. The normal world consumption of timber still exceeds the possibilities of natural growth of forests which are economically capable of exploitation at predepression price levels. Timber prices will have to go much higher than they have been, if the forests of central Asia or the Amazon or Congo basins are ever to contribute an important share of the world's timber trade. Altogether, a survey of world consumption and world trade in wood shows no evidence of permanent diminution, except in the United States, where consumption for a century was abnormally high because abundant supplies were available to meet the needs of the rapidly growing population, transportation systems, and industries.

USES OF WOOD ARE CONSTANTLY CHANGING

Wood is one of the most flexible of organic products. This accounts for its adaptability to the many uses for which it has been employed by mankind at different stages of his economic and social development.

The form in which wood is used has undergone many changes in historic times—from the crudest of wooden implements to the most complex of chemical compounds. Even in the comparatively short lapse of time since the settlement of this country, it has evolved through many different shapes. The Indian used the bark of trees to make his tepee; the settler used logs to build his cabin. Later, logs were sawed into lumber, which was used in the construction of houses, furniture, and in other commodities of everyday life. A comparatively recent development is the use of wood for making paper. Recently more and more wood has been converted into veneer and into pulp, out of which are fabricated boards, insulating materials, artificial silk and leather, and many other commodities. The changes in the use of wood reflect not only the state of technical development of a country but also its economic structure and mode of life. A decline in the consumption of wood in any particular form, or for any particular use, therefore, will not be conclusive evidence that need for wood is decreasing.

As a country ascends from a primitive pastoral culture to a highly industrialized state, the demand for wood, particularly structural timber, tends to increase. This tendency is checked as supplies become more limited and prices increase. Competing materials then take the place of wood to a greater or less extent in many of its uses. On the other hand, they may cause increased demand for wood in other forms. As wood has lost ground in some fields of use, new uses have arisen in which it continued to be an indispensable material.

RAILROADS

The railroads which carried coal to replace wood as fuel made greater and greater demands upon wood for ties, as well as for cars and construction of buildings and platforms.

MINING

Mining of coal demanded increasingly larger quantities of mine timbers. The use of wooden props in mines began to develop toward the end of the eighteenth century. As the coal industry grew, the import of mine timbers into such countries as England and Germany also increased. The importation of mine timber into England during the period 1901–05 averaged more than 106 million cubic feet a year. During the period 1909–13 it rose to more than 147 million cubic feet.

PULP AND PAPER

The use of wood for paper dates from about 1850. The paper industry, based on wood, made a phenomenal growth, particularly in the last 20 years. In 1911 the world production of wood pulp was 7,679,000 tons. In 1929 it has increased to 18,478,000 tons, or over 140 percent. (See table 8.)

TABLE 8.—*World production of wood pulp in 1911 and 1929* [1]

Country	Production 1911	Production 1929	Country	Production 1911	Production 1929
	1,000 short tons	*1,000 short tons*		*1,000 short tons*	*1,000 short tons*
United States	2, 643	4, 519	Japan	77	661
Canada	489	3, 859	Russia	165	293
Sweden	1, 056	2, 800	Other countries	1, 117	1, 860
Germany	1, 345	2, 258			
Finland	249	1, 183	Total	7, 679	18, 478
Norway	538	1, 045			

[1] Streyffert, Th. Världens Barrskogstillgångar. Stockholm, 1931.

The average world per capita consumption of paper in 1925–27 was in the neighborhood of 23 pounds, ranging all the way from 192 pounds in the United States to less than 1 pound in China. Should the teeming masses of Asia alone reach the world average of 23 pounds, the paper production of the world would have to be increased by 10 million tons to meet Asia's needs alone. Japan has already increased its pulp production from 77 thousand tons in 1911 to 661 thousand tons in 1929, or more than 750 percent. The fact that the per capita consumption of pulp was increasing, up to 1929, in such countries as the United States, Great Britain, and Germany also is an indication that even in the industrial countries the possibilities of growth have not yet reached a limit. (See table 9.)

TABLE 9.—*Annual consumption of paper in various countries, 1925–27*

[Based on Streyffert, Världens Barrskogstillgångar. Stockholm, 1931]

Country	Consumption per capita	Country	Consumption per capita
	Pounds		*Pounds*
United States	192	Austria	39
Canada	92	Italy	22
England	92	Japan	17
Sweden	68	Estonia	12
Germany	59	Poland	9
Denmark	58	Greece	8
Belgium	51	Yugoslavia	8
Norway	42	Russia	6
Netherlands	42	Rumania	5
Finland	41		

CONTAINERS

Another use for which wood came into demand was in the manufacture of containers for shipment of foodstuffs, such as eggs, butter, fruit, vegetables, and canned goods, and of various other commodities, in both foreign and domestic commerce. The growing dependence of industrialized countries upon foodstuffs and raw materials of other countries, and their exportation of manufactured products to other countries, created a large international demand for wood for packing purposes. In the United States, wooden boxes and crates in 1928 absorbed about one seventh of the entire lumber cut. In some years they have absorbed as much as one fifth of the lumber cut. Although there has been a decline in the consumption of boxes and crates since 1918, it was still 10 percent higher in 1928 than in 1912.

VENEER AND PLYWOOD

Great advances have been made in the manufacture of veneer and plywood products. Gluing processes have been invented which greatly facilitated the production of plywood, panels, and all sorts of laminated sheet material. The development of the veneer industry came first in Europe and has shown a rapid growth. Plywood has become a forest product of considerable importance in world trade. The veneer industry in the United States has increased greatly in output since 1905. Over 181 million board feet of logs were used for veneers in 1905; by 1929 the consumption increased to 1,112 million board feet, or by more than 500 percent.

RAYON

Artificial silk or rayon, much of which is made from wood, came into use only since 1900. In 1911 only about 2 million pounds was consumed in the United States. In 1929, the United States consumed more than 60 times as much as in 1911.

WALL BOARD

New uses of wood in the form of wall board and insulating materials are appearing constantly. No one can forecast at present what their future development may be. These new products, like fiber containers, veneer, and wall board, often take the place of wood in its original form for similar uses. Often, however, the new products, like rayon, cellophane, and other viscose products, create new fields in which wood was not originally employed.

CONSTRUCTION

Even in the old fields in which wood has been used for a long time, it has not given way to other materials to the extent that has sometimes been supposed. Wooden dwellings still predominate in many parts of the United States and also in parts of many other countries. Even in the construction of brick or concrete houses large quantities of lumber are ordinarily used. Wood still plays an important part in the construction of dwellings in European countries as well as in this country. Within recent years there has been a revival in the use of wood for construction in Europe. Types of wooden construction have been developed in which, instead of large timbers, small wooden pieces connected in a lattice-like or truss-like manner, or built up into laminated beams by the use of glue or bolts, are used. By means of such combination of small wooden pieces, it is possible to span considerable distances. One great advantage of the use of wood in such construction lies in its relative cheapness. The small size of the pieces makes it possible to saw them out of small logs and, consequently, to utilize small timber where before only large logs could be used. Similar types of construction are being developed in this country. New ideas of engineering have also penetrated the technique of building small wooden dwellings. These new architectural ideas are opening up new and more economical uses of wood in the fields where iron and concrete have been considered the only suitable materials.

THE WORLD TIMBER SUPPLY IS DECREASING

Contrasted with the tendency of world wood consumption to rise or at least to maintain itself is the rapid shrinkage in the world supply of timber, particularly coniferous timber. The coniferous softwood forests of the northern temperate zone are drawn upon by nearly all countries of the world to meet the greater part of their needs for construction timber and pulpwood. These forests have been progressively decreasing in extent from the Middle Ages up to the present time. Even within the last 40 years before the World War, the destruction of the forests of the temperate zone continued at a rapid rate. The forest area of Norway, for instance, decreased 11 percent between 1875 and 1907. In European Russia 20 million acres of forest were destroyed in the 33-year period from 1880 to 1913, and the same process went on in Finland. During and after the war this destruction was greatly accelerated in Russia.

Even more serious than the reduction in forest area is the reduction in timber supply and in growth capacity of the area that remains in forests. At least one third of the timber consumed by the world in a normal year is supplied by diminishing the forest resource, only two thirds being replaced by growth. As a result of the continued depletion of the original forests, only a few countries still have supplies of coniferous timber in excess of their own needs.

The three countries with the largest softwood timber resources are Russia, Canada, and the United States. Together they embrace some 80 percent of the coniferous forest area of the world. Before the war these three countries furnished more than one half of the entire world export of softwood lumber. Both in the United States and in Canada, the annual cutting, combined with fires and losses from insects and disease, greatly exceeds the annual growth. Sweden, Finland, Poland, and the countries of central and southeastern Europe cannot materially increase their exports of wood. In fact, most of them cannot long keep up the present rate of exportation if they are to satisfy their own requirements.

The wood-importing countries of western Europe rely on Russia to a considerable extent for their present and future supplies of coniferous timber. It is most alarming, therefore, to learn from recent studies that Russia, with an estimated two fifths of the world's coniferous forest area, and whose timber resources were supposed to be virtually inexhaustible, faces the end of her readily accessible timber supply in Europe within 10 to 20 years and in western Siberia within the next 35 years. Yet Russia herself is just on the threshold of a vast industrial expansion.[7]

Under the pressure of meeting present-day needs, the Russian forests are being cut recklessly, with little or no provision for future regrowth. Fires sweep over the land that has been logged, and also destroy many thousands of acres of uncut timber. The acreage of cut-over land that has not come up to second growth, together with the windfalls and the burns, according to Russian foresters, amounts in the Soviet Union to some 125 million acres. If this is the picture of Russia, the most heavily forested Temperate Zone country in the world, upon which most of the poorly forested countries have to depend for their imports, then the prospects for the future supply of coniferous timber are dark indeed.

WORLD WILL CONTINUE TO NEED WOOD

The present relatively low level of wood consumption in many of the industrial countries of Europe does not signify that their wants are completely satisfied, but rather that existing economic conditions are such that they cannot be satisfied. There is a wide field for improvement in living conditions of the great masses of European people. There is need for better rural and urban housing in nearly all of these countries. As their standards of living improve—and it would be unduly pessimistic to assume that living standards will not rise in the long run—there will be an increased demand for wood.

Moreover, the fact should not be overlooked that industrial development still lies ahead for most of the world excepting Europe and North America. Russia is now in the process of industrialization, and expects to double or treble her wood consumption in the next few years. The continent of Asia is still on the threshold of industrial expansion. A very small increase in the per capita rate of wood consumption in these populous countries will mean a large demand in the aggregate. Industrialization has always been accompanied by increased use of timber.

For building construction, for pulp, and for many other industrial uses, softwoods are preferred. This preference seems likely to continue if softwood timber is available. The hardwoods of the Tropics can supply many needs and they might even conceivably be utilized for most of the purposes for which softwoods are now employed. Nevertheless, it is not likely that they can ever be supplied cheaply enough to bring about their use, in the countries of the North Temperate Zone, on a scale comparable to the present consumption of softwoods.

Indications are that the accessible softwood forests of the world cannot continue indefinitely to supply the world's present normal demands, to say nothing of an increasing demand. They can do this only if a much larger area than at present is managed definitely for timber production and especially for the production of high-grade material. Such material is likely always to command a premium in world markets. Of all the coniferous forest regions in the world, the yellow pine region of southeastern United States and the Pacific coast forest of western United States and Canada are probably the most favorably situated to compete for world markets. They are second to none in rate of timber growth, in possible yields, and in quality of timber, and they are strategically located with reference to ocean transportation that is possible throughout the year.

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[7] Buchholz, E. Die Wald und Holzwirtschaft Sowjet-Russlands. Berlin, 1932.

It is for these reasons that the decline in rate of timber consumption in the United States, even if it continues, should cause no great anxiety as to the future markets for wood. Nor, on the other hand, should the temporary economic situation in the world timber trade cause one to fear that our domestic market will be threatened indefinitely with a flood of cheap foreign wood. With world needs for wood and especially for softwoods, outside of the United States, tending to increase, and with the world's softwood resource steadily diminishing, there is no reason to believe that the United States can obtain its future supplies from any other country more cheaply than it can grow its own timber. There is every reason to believe that there will be a ready demand, at home or abroad, for all of the wood that will be grown in American forests.

WATERSHED AND OTHER SERVICES AND PRODUCTS OF THE FORESTS

The discussion of our forest land resource brought out the concept of the forest as a complex biological unit serving a wide range of highly important economic and social functions. Wood production has, until recently at least, usually been considered the primary forest use. In many cases, however, other functions actually take precedence, and in the aggregate, for the entire country, may outweigh in importance timber production. With some exceptions these uses are not conflicting and several or all may, with proper correlation, be served at the same time. It is the purpose of the following sections to appraise the various uses and to correlate them with each other.

The discussion of watershed and the clearly related forest influences analyzes the manner in which these influences are exerted and their extent, and presents a survey of the 17 principal watersheds into which, for this purpose, the United States is divided. Succeeding sections evaluate the recreational services of forests and the area that may need eventually to be reserved with this as the primary use; outline the scope, importance, and outstanding problems pertaining to the forage and wild-life resources of the forest; and describe a number of the secondary by-products.

The discussions in this third main part of the report complete the presentation of our forest resources.

WATERSHED AND RELATED FOREST INFLUENCES

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The forests of the United States, invaluable as a source of wood and other tangible products, have so-called "intangible" values perhaps equally great. The present section will describe the value of the forests as regulators of stream flow and preventives of erosion.

STREAM FLOW AND EROSION PROBLEMS OF NATIONAL IMPORTANCE

Practically every section of the country is confronted by one or more serious problems of stream flow or erosion. The densely populated areas share with the areas of low rainfall the immediately vital problem of obtaining adequate and constant quantities of water for human consumption and other domestic uses. The latter areas are confronted with the additional problem of supplying water for irrigation of agricultural land. Populous industrial communities require water, often in huge quantities, for various manufacturing processes. Large sections of the country that receive light in their homes and energy in their factories from water power are concerned over low water in the streams. The threat of low water and clogged channels must also be considered by those portions of the United States where stream-borne commerce is important and navigable harbors give access to the markets of the world. Floods are often an appalling problem not only to the great fertile lowlands but also to highland valleys. And erosion—the washing of precious surface soil from land exposed to rain and melting snows—is a problem common to nearly all parts of the United States and acute in many. The magnitude of the problems of stream flow and erosion, considered in detail and region by region later in this discussion, may be judged for the Nation as a whole from the paragraphs immediately following.

DOMESTIC AND INDUSTRIAL WATER SUPPLIES

Very heavy concentration of population and industry in certain areas, such as the North Atlantic seaboard, the Ohio River Valley, and parts of California, has created a demand for huge public water supplies. The main urban centers from Boston to Baltimore consume 2,000,000,000 gallons of water daily; in the Philadelphia district more than half of the consumption is by industrial plants. Boston plans to tap a stream 60 miles away; New York now goes 92 miles for part of its supply. The investment of New York in dams and reservoirs is $66,000,000; the adjacent communities in New Jersey plan a development to cost about $45,000,000; Baltimore is at work on a $30,000,000 project.

The great drought of 1930–31 in the northeastern United States revealed the acuteness of the domestic water-supply problem, bringing not only great actual inconvenience to rural and urban populations alike, but in the cities raising the specter of epidemics and uncontrollable fires. For example, while some farmers in western Kentucky were hauling water for livestock 20 miles, the public water supplies of several towns and cities in the Ohio Valley had to be supplemented by shipments in tank cars. Among them was Lexington, Ky., which, after drawing water by trainloads from pools in the Kentucky River for several weeks, constructed a 25-mile pipe line to the same source. The United States Weather Bureau at Cincinnati in its report on the Ohio Valley situation in October 1930, stated:

> Fortunately the Federal Government had completed the dams in the Ohio River before the great drought of 1930. These dams have maintained full pools from Pittsburgh, Pa., to Cairo, Ill., during the entire summer and fall. * * * Many of the larger tributaries * * * have been improved by dams. The water from the pools in these rivers has made it possible for life to exist and business to progress in the Ohio Valley during the driest season of record.

San Francisco and the immediate vicinity will shortly obtain part of their public water supplies from the Hetch Hetchy Reservoir, 200 miles away, built at a cost of $126,500,000. In southern California half the population of the State, concentrated in an area where less than 1 percent of the water of the State is found, now obtains part of its domestic water from the Owens River, 250 miles away, and is preparing to go 200 miles to the Colorado River. Some of the deep wells from which part of the water supply for this area is obtained are being depleted or threatened with invasion by the salt waters of the Pacific Ocean, just as the deep wells of the New Jersey coast resorts are threatened by those of the Atlantic Ocean. The water system by which southern California plans to solve its water problems, primarily of domestic supplies, will cost $350,000,000.

IRRIGATION

Irrigating water is the lifeblood of certain communities, such as southern California and the Salt River Valley in which is concentrated one fifth of the population of Arizona. It is a commodity of enormous importance to 19 States west of the Mississippi River, as is indicated in table 1. Irrigation has been the purpose for which the Federal Government has constructed a number of large reservoirs, such as Elephant Butte in New Mexico and the Arrowrock in Idaho.

TABLE 1.—*Acreage of irrigated land, together with value of lands, buildings, and machinery, and value of irrigation enterprises for irrigated farms, by States. 1930 Census*

State	Irrigated area	Value of lands, buildings, and machinery	Value of reservoirs and distributing systems
	Acres	*Dollars*	*Dollars*
Arizona	575, 590	157, 290, 710	73, 328, 197
Arkansas	151, 787	18, 417, 482	6, 836, 648
California	4, 746, 632	2, 535, 075, 016	450, 967, 979
Colorado	3, 393, 619	414, 180, 910	87, 603, 240
Idaho	2, 181, 250	316, 649, 034	84, 500, 354
Kansas	71, 290	13, 095, 069	1, 685, 652
Louisiana	450, 901	50, 676, 224	15, 744, 743
Montana	1, 594, 912	205, 027, 415	50, 319, 204
Nebraska	532, 617	91, 773, 733	21, 386, 319
Nevada	486, 648	63, 998, 051	15, 457, 931
New Mexico	527, 033	93, 160, 485	19, 834, 380
North Dakota	9, 392	1, 452, 335	1, 267, 314
Oklahoma	1, 573	1, 771, 383	160, 099
Oregon	898, 713	171, 919, 001	38, 754, 548
South Dakota	67, 107	11, 576, 300	4, 502, 117
Texas	798, 917	190, 141, 304	49, 022, 164
Utah	1, 324, 125	212, 258, 249	35, 669, 819
Washington	499, 283	208, 738, 027	40, 561, 895
Wyoming	1, 236, 155	129, 692, 056	35, 153, 187
United States	19, 547, 544	4, 886, 892, 784	1, 032, 755, 790

WATER POWER

Power developed from streams has long been the backbone of the great manufacturing industries of New England and New York and of late years has made possible the industrial rise of the Carolinas. As a source of electric current for countless homes, rural and urban, and for city lighting, it is important in all but a few sections of the United States. Dams built to store water for power production rank among the Nation's great engineering feats. That at Dreher Shoals, S.C., created a reservoir with a capacity of 524 billion gallons of water. The Wilson Dam at Muscle Shoals, Ala., cost the United States $51,000,000 to build; the recently completed Conowingo Dam in Maryland cost $52,000,000 and has an installed capacity of 378,000 horsepower. Practically every State in the Union utilizes power from its streams, and the 26 States listed in table 2, scattered from Maine to California, have each developed over 100,000 horsepower.

TABLE 2.—*States developing more than 100,000 horsepower from stream flow*

State	Installed capacity, 1931	State	Installed capacity, 1931
	Thousand horsepower		*Thousand horsepower*
California	2, 321	Massachusetts	362
New York	1, 904	Idaho	357
North Carolina	954	Oregon	354
Alabama	931	Pennsylvania	291
Washington	892	Tennessee	288
South Carolina	816	Minnesota	286
Maine	579	Vermont	202
New Hampshire	553	Iowa	182
Wisconsin	519	Connecticut	171
Georgia	482	Utah	157
Montana	429	Kentucky	145
Maryland	416	Arizona	137
Michigan	399	Virginia	135

NAVIGATION

Water transport plays an important role in the distribution of goods in some parts of the United States. The inland waterways of the country, exclusive of the Great Lakes and interior and intracoastal canals, carried 130 million short tons of freight in 1929. From the founding of the Republic the improvement and maintenance of navigable channels and harbors has been a Federal responsibility. Immense sums have been spent by the War Department in the deepening and widening of natural channels, and in engineering works to make navigation possible during periods of low water. On a single stream—the Ohio River—the Army engineers built 49 locks and dams, at a total cost of some $118,000,000. The sums spent by the Federal Government on existing river and harbor projects, nearly all begun during the last 50 years, are shown in table 3 for each of the drainage regions later described in detail.

TABLE 3.—*Expenditures by the Federal Government on existing river and harbor projects directly connected with stream flow to June 30, 1932* [1]

Drainage region	New work	Maintenance	Total
Northeastern	$110, 565, 800	$41, 549, 614	$152, 115, 414
South Atlantic	21, 925, 180	10, 664, 800	32, 589, 980
East Gulf	42, 431, 263	24, 890, 899	67, 322, 162
West Gulf	7, 840, 354	6, 842, 644	14, 682, 998
St. Lawrence	23, 536, 783	7, 831, 504	31, 368, 287
Upper Mississippi	46, 453, 997	17, 964, 551	64, 418, 548
Hudson Bay			
Ohio	273, 377, 283	8, 005, 056	281, 382, 339
Missouri	55, 694, 195	11, 443, 112	67, 137, 307
Arkansas-Red	9, 530, 642	5, 371, 173	14, 901, 815
Lower Mississippi	24, 698, 131	14, 933, 296	39, 631, 427
California	19, 694, 023	8, 980, 092	28, 674, 115
Columbia	20, 008, 737	8, 997, 023	29, 005, 760
Colorado			
Great Basin			
Rio Grande			
Cascade	12, 876, 149	8, 345, 876	21, 222, 025
Total	668, 632, 537	175, 819, 640	844, 452, 177

[1] Obtained from the Annual Report of the Chief of Engineers, U.S. Army, pt. I, 1932. Sums spent on harbor breakwaters, canals, and other similar improvements not connected with natural streams and hence not influenced by cover conditions have been omitted from the compilation.

FLOODS

Floods on the lower Mississippi River of the magnitude of that of 1927, which inundated 18,000 square miles, drove 750,000 people from their homes, did some $300,000,000 worth of damage, and took 246 lives, so far overshadow disasters on lesser streams as to obscure the almost Nation-wide importance of local floods. Flood damage in South Carolina has averaged nearly $1,000,000 a year for the last 20 years, and in Tennessee has been about the same. In table 4 are given some of the major floods occurring in the present century on streams other than the Mississippi River, but the record is far from complete.

TABLE 4.—*Partial summary of disastrous local floods since 1900 and reported damage*

Stream or locality	Date	Lives lost	Reported damage
		Number	
Passaic River, N.J.	1903		$4,000,000
North Canadian River, Okla.	1932		1,050,000
New England	1927	84	35,000,000
Paint and Armstrong Creeks, W.Va.	1932		2,500,000
Choctawhatchee River, Fla.	1929		5,000,000
Delaware River	1925		1,800,000
Brazos River, Tex.	1921	164	12,000,000
Kentucky River, Ky.	1927	67	7,000,000
Ohio River Valley	1913	400	180,000,000
Upper Mississippi River	1916		2,500,000
Wabash River, Ind., and White River, Ill.	1930		7,000,000
Western North Carolina	1916		22,000,000
Pueblo, Colo.	1921	120	25,000,000
Spartanburg, S.C.	1903	50	3,500,000
Rio Grande, Tex.	1932	12	2,500,000
Yazoo, Miss.	1932		1,450,000

EROSION

A process common to nearly all parts of the United States is the washing by rains from unwisely cleared and unskillfully cultivated lands, from overgrazed pastures and ranges, and occasionally from devastated and badly burned forest lands of the fertile topsoil that has required centuries and sometimes vastly longer periods to accumulate. In some places the effects of this washing have reached tragic proportions. Erosion not only robs the uplands of fertility but loads the streams which drain them with silt and heavier material that clogs irrigating ditches, navigable channels, and harbors; fills reservoirs; increases the height of floods; and permanently ruins much overflowed land. Erosion is unquestionably most serious from land cleared for agriculture. So much of this land as fully justifies the careful management necessary to prevent erosion will remain in agriculture and is beyond the scope of this report. But on the piedmont plateau of the Southern States, on the rich bluff lands of the Mississippi as far north as Wisconsin, in the high valleys of the Appalachian Mountains, in the States bordering the Ohio River, in Missouri, Oklahoma, and eastern Texas, and in other agricultural sections of the United States erosion has been the chief cause for abandoning millions of acres of cleared land. All of this will continue to erode unless reclothed in permanent vegetation, such as forest or brush. Over the wide expanse of the public domain unregulated grazing has started erosion that has already seriously reduced the value of the forage and shortened the life of irrigating reservoirs.

DOES FOREST COVER AID IN SOLVING THE PROBLEMS OF STREAM FLOW AND EROSION?

No one can question the seriousness of the stream flow and erosion problems that confront practically every section of the United States. Does the condition of the forest cover on the watersheds of streams appreciably influence stream flow and erosion, and how far may forest management be expected to aid in solving these problems?

DEFINITION OF FOREST COVER

Forest, as the term is used here and elsewhere in this report, includes both trees proper and tall brush. In the West this embraces commercial timber, woodland (pinon and juniper, for example), and chaparral—all areas except sagebrush, grassland, and other comparable prairie or desert types of vegetation. In the East it covers such degenerate forest types as scrub oak. In calculating the percentage of a drainage region which is forested, small openings within the forest have been included with the forest, but large meadows, grassland, or other non-tree-producing openings within the forest have been excluded. Windbreaks, shelter-belts, and other tree plantings carried in the census records of the Plains region as woodlots are admitted to the forest area. Cleared lands within the forest belt which have been permanently abandoned or are in process of abandonment by agriculture have been classed only as potential forest land.

Forest cover in its relation to watershed protection is considered to include: (1) The trees and tall brush; (2) the herbs and shrubs growing thereunder or in openings in the forest or brush fields; (3) the litter, or fallen leaves, branches, down trees, and other vegetative material on the forest floor; and (4) the rich humus of partly decayed vegetable matter at the surface and in the top layer of the soil. Thus in this section it is the influence of the entire forest cover upon run-off, erosion, or other watershed-protection values which is given consideration, rather than the influence of the trees alone.

There is a rather widespread popular acceptance in this country of the idea that forests and associated or related vegetation exert a favorable influence not only on streams but on climate. This probably had its origin in European experience, and has been fortified by general observation, such as the muddiness of streams flowing from cleared land compared with the clarity of those flowing from woodland, and extreme fluctuations in the rate of streamflow from deforested or denuded land. Only of late has a body of information based on careful observation and experimentation begun to accumulate behind the popular concept of the forest as a regulator of stream flow and preventive of erosion.

This concept of the beneficial influence of forests has been embodied from the first in the administration of the national forests created from the public domain, and was long the sole basis for purchase of national forests in the East. The act of 1897, which first provided for administration of the original "forest reserves", named as a major purpose "securing favorable conditions of water flows". Certain of the national forests of the West—among them the Tonto in Arizona and the Angeles in California—have been created in whole or in large part principally for the protection of irrigation projects or municipal water supplies. The Weeks Law of 1911 provided for Federal cooperation with the States "for the protection of the watersheds of navigable streams", and for Federal "acquisition of lands for the purpose of conserving the navigability of navigable rivers." The Clarke-McNary Law of 1924 continued the cooperation "with a view to the protection of forest and water resources", and directed that in further purchases "due consideration" be given both to watersheds of navigable streams and those "from which water is secured for domestic use or irrigation." Nearly 60 percent of the Federal purchases of forest land made since 1924 have been made primarily for watershed protection.

In direct opposition to the popular idea regarding beneficial forest influences have been the doubts from time to time implied or expressed by various small groups of engineers, geologists, and meteorologists. The Mississippi River Commission, for example in its 1927 plans for controlling floods in that stream, set up grounds "to justify rejection of reforesting as an element of flood control in the lower Mississippi River", and has ignored the possibility that proper management of the 20 percent of the watershed still in forest may reduce flood crests by the critical feet or inches that often spell the difference between mere high water and disaster. Other men of scientific standing from time to time attempt to prove that because forests and similar vegetation are well known to appropriate to their use considerable quantities of ground water, particularly at seasons when streams are low, their influence is detrimental rather than beneficial. In the face of criticism of this character it is desirable to summarize here the more important available experimental evidence on the relation of forests to stream flow under American conditions of climate, soil, and vegetation.

HOW FOREST COVER INFLUENCES RUN-OFF

The average yearly rainfall (including snow) in the United States varies from less than 10 inches in the more arid portions of the Southwest to more than 100 inches in the Pacific northwest and in portions of the southern Appalachian Mountains. In some parts of the country the rainfall is concentrated within a few months, or in a few heavy storms, while in others it is so well distributed that the precipitation for the wettest month is rarely more than twice that for the driest month. These figures are averages for a period of years; irregularities—both excesses and deficiencies in rainfall, often of extraordinary magnitude—are common to practically all sections of the country, although particularly marked in a few.

Whether the rain and snow falling on any watershed is as fully useful to mankind as it might be depends almost wholly on the character of its run-off. Of that which sinks into the ground—that is, is absorbed by the surface soil or percolates through it to greater depths—the greater part becomes available for the growth of plants useful to man or his domestic animals, or in time appears in streams capable of furnishing fairly constant supplies of water for domestic, industrial, and irrigating use, of generating water power, and of transporting freight. Or it may be stored in natural underground reservoirs available to human use. The precipitation which quickly reaches the streams by flowing over the surface of the ground, on the other hand, causes much erosion and many floods. This general classification of subsurface run-off as useful, and flashy surface run-off as detrimental, is of course subject to many exceptions. Not all vegetation using rain that has penetrated the ground is directly useful to us, and some of this water is lost through chemical combination in the soil and through seepage to great depths. Even subsurface waters when they reach the streams may contribute to floods, and the flashy run-off under some conditions may be stored above or below ground, and thus be prevented from causing destructive floods or being lost to human use during dry seasons. These instances are, however, so exceptional and the beneficial effects for which they are responsible are so slight in comparison with the damage ordinarily wrought by run-off that they may be dismissed here as entirely negligible.

Studies of surface run-off from forested areas, and from areas in other types of natural or planted vegetation have been made in Wisconsin and in Mississippi. On silt loam uplands in Wisconsin[1] with slopes averaging 36 percent, the proportion of total summer precipitation which ran off over the surface of the ground beneath hardwood forests of varying density averaged 2.8 percent. Wild pastures of native grasses, in which the soil had never been cultivated, showed a surface run-off about 2½ times as great. Cultivation greatly increased the percentage of surface run-off; from cultivated hay fields it averaged 17.7 percent, and from small grain fields, cornfields, seeded pastures, and fallow land it averaged over 25 percent.

H. G. Meginnis of the Southern Forest Experiment Station made a study of run-off and erosion from the upland loess soil of northern Mississippi by means of a number of sample plots. At the time of the disastrous flood in the Yazoo River in 1931–32 when 27 inches of rain fell, 62 percent of the rain ran off immediately from the plots located in cultivated fields, and 54 percent from those located in abandoned fields. The run-off during the same period from the plots in an undisturbed oak forest was only 0.5 percent and but 2 percent in a scrub oak forest.

Total run-off can of course be measured only at the foot of slopes, or wherever the precipitation which has percolated into the ground is again brought to the surface by the outcropping of bedrock or impervious soil layers, and joins that which has run off over the surface. The volume of streams, compared with the precipitation received by the watershed above the point where stream volume is measured, indicates total run-off only so far as there is no deeper movement of moisture in the soil beneath the stream channel. In the drier portions of the United States stream flow for an entire year may be as little as 6 percent of the total precipitation on a watershed,[2] although averaging more, but in the more humid portions is almost always higher. In the Middle West—Missouri and Illinois, for example—the total run-off as measured by surface flow averages 20 to 30 percent[3] with minima of probably 15 percent. In the East the average total run-off in streams is more nearly 50 per cent of the precipitation and rarely drops below 25 percent. King[4] gives the average percentage run-off for Tennessee rivers as 45 percent with extremes of 12 and 66 percent.

The principal factors which influence the normal division of run-off into useful subsurface waters and less useful or destructive surface waters are the character of the precipitation, the geology and topography of the surface on which it falls, and the vegetative cover on that surface. The vegetative cover is the only one of these factors which it is within human power to control. Hence the necessity for understanding how it operates. Forest is the cover on by far the greater part of the United States which is still in natural vegetation, and on which important quantities of rain or snow fall. The more important ways in which they bring about their total effect on run-off are explained in the following paragraphs.

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[1] Bates, C. G., and Zeasman, O. R. "Soil erosion." Wisc. Agr. Exp. Sta. Research Bul. No. 99, 1930.

[2] Blaney, H. F. "Discussion of 'forests and streamflow'." Proc. Amer. Soc. Civil Eng., Dec. 1932.

[3] Duley, F. F., and Miller, M. F. "Erosion and surface run-off under different soil conditions." Mo. Agr. Exp. Sta. Research Bul. No. 63, 1923.

[4] King, W. R. "Surface waters of Tennessee." Div. of Geol. Dept. of Educ. Bul. 40, 1931.

INTERCEPTION OF PRECIPITATION

Anyone who has taken refuge under a tree during a summer shower knows that the crown of both evergreen and broadleaf trees intercepts and holds a certain amount of the rain, which is later evaporated, but that if the rain is prolonged until the leaves and branches are thoroughly wet, the remainder of the fall reaching the tree drips and is not caught but only delayed in reaching the ground.

The Forest Service has recorded rainfall at paired stations inside and outside of timber stands in several forest types. Records of 3 to 5 summers show that a good pulpwood stand of spruce, fir, and some paper birch in Maine intercepted 26 percent of the rainfall; another Maine stand of pure spruce-fir, 37 percent; a dense saw-timber stand of white pine and helmock in Massachusetts, 24 percent; and a heavy virgin white pine and hemlock stand in Idaho, 21 percent. Briefer studies record that open second-growth forests of oak and hard pine in southern New Jersey intercepted 13 percent of the summer's rainfall; and jack pine and hardwood-hemlock stands in Wisconsin, 22 and 19 percent, respectively, of the spring and fall precipitation. The Wisconsin hardwoods when in leaf intercepted 25 percent, as against 16 percent after the leaves fell.

Interception of snow by the crowns of ponderosa pines at about 4,500 feet elevation, in Idaho, was studied by the Forest Service during 1931–32. In a good stand of virgin timber with an understory of young trees, C. A. Connaughton found that up to the time of maximum storage 27 percent of the winter's snow had been intercepted; in similar mature timber without an understory it was 22 percent; and in a somewhat open stand of ponderosa and lodgepole pine, 20 to 30 feet tall, 8 percent. Studies by Church,[5] Jaenicke and Foerster,[6] and Griffin,[7] however, indicate that snow interception is considerably less in evergreen forest types elsewhere in the West.

RETARDATION OF SNOW MELT

Although MacKinney [8] found that light snows melted more rapidly on litter than on mineral soil under a pine plantation in Connecticut, in regions of heavy snow a forest cover retards melt in the spring, thereby materially lessening destructive surface run-off and promoting percolation of the melted snow into the ground. This is due in part to shading of the ground, but mostly to reduction in wind movement; Connaughton found the wind movement during the period of rapid snow melt in Idaho to be more than nine times as great in the open as in the heavy stand of mature ponderosa pine with an almost continuous understory of advance reproduction. Even in the open ponderosa pine forest in which Jaenicke and Foerster worked the wind movement was less than half that in the open.

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[5] Church, J. E. Jr. "The conservation of snow. Its dependence on forests and mountains." Scientific American Supplement, Sept. 7, 1912.

[6] Jaenicke, A. J., and Foerster, M. H. "The influence of western yellow pine forest on the accumulation and melting of snow." Mo. Weather Rev., Mar., 1915.

[7] Griffin, A. A. "Influence of forests upon the melting of snow in the Cascade Range." Mo. Weather Rev., July, 1918.

[8] MacKinney, A. L. "Effects of forest litter on soil temperature and soil freezing in autumn and winter." Ecology, July, 1929.

The following information on retardation of snow melt was obtained in the snow studies just cited. In Idaho the snow cover disappeared in the forest from 3 to 10 days later than in the open; at least 10 days later in Nevada; "several weeks" later in Arizona, the snow occurring, however, merely as drifts in the timber; and from 1 to 5 weeks later in Washington. Ashe [9] reported that 20 inches of snow falling at an elevation of 600 feet in Maryland during March 1906 was 9 days longer in melting beneath a cover of Virginia pine than in the open, and also longer though by a smaller interval beneath an oak forest than in the open.

REDUCTION OF EVAPORATION FROM THE SOIL

In addition to intercepting precipitation and retarding snow melt, the crowns and trunks of trees greatly reduce the rate of evaporation from the soil, just as they have been seen to lessen evaporation or sublimation of snow. In regions of low rainfall, where the forest is open and litter is not continuous or deep on the forest floor, reduction in evaporation from the soil is very much to be desired. W. C. Lowdermilk found, in an analysis of factors affecting the yield of water from watersheds in southern California, in 1930, that if all rain in southern California were to occur as 0.5 inch storms one week apart evaporation would account for practically the total supply of meteoric waters. Although half an inch of rain may penetrate the soils of this region to a depth of about 8 inches, when the surface is dried by sunlight and wind, the moisture is drawn up by capillary action and is evaporated. Burr [10] also found on cultivated ground in Nebraska that a half-inch rain was of no storage value unless it fell on a surface still moist.

Fortunately, all the rain does not occur in California, Nebraska, or anywhere else in the United States in small storms at weekly intervals, and evaporation from the soil is universally influenced by a forest cover which not only shades the ground but greatly reduces wind movement. In Arizona, according to Pearson,[11] summer evaporation a few feet above the ground within a forest of ponderosa pine may be only 70 percent of the evaporation in the open. G. M. Jamison found that during July and August 1931, evaporation beneath a dense virgin forest of western white pine and hemlock in Idaho was only 22 percent of that in an area clear-cut and burned, and in a similar stand from which about 65 percent of the cover had been removed it was only 47 percent. Bode [12] states that in a heavy oak stand in Iowa summer evaporation was 47 percent, and in a reproducing cut-over area 74 percent of that in the open. O. M. Wood found that evaporation during one spring in a rather open, short-bodied stand of mature pine and oak in southern New Jersey was only 65 percent of that in the open.

It is impossible to state what effect these very substantial reductions in evaporation rate within the forest have upon soil moisture. There are almost no American data on seasonal evaporation from a bare soil, and they would not apply to the normally litter-covered soil of a forest. European evidence, as quoted by Zon,[13] shows wide variations, but indicate that evaporation from bare soil in the open, under average conditions, amounts to about 50 percent of precipitation; and that a forest, even without leaf litter, may reduce this to 15 to 25 percent.

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[9] Ashe, W. W. "Relation of soils and forest cover to quality and quantity of surface water in the Potomac basin." U. S. Geol. Sur. Water Supply Paper No. 192. 1907.

[10] Burr, W. W. "The storage and use of soil moisture." Nebraska Agri. Exp. Sta. Research Bul. no. 5. 1914.

[11] Pearson, G. A. "Forest types in the Southwest as determined by climate and soil." U.S.D.A.Tech. Bul. no. 247. 1931.

[12] Bode, I. T. "Relation of the smaller forests area in nonforested regions to evaporation and movement of soil water." Proc. Iowa Acad. Sciences. 1920.

CONSUMPTION OF WATER BY FOREST VEGETATION

The water which all plants rooted in the soil withdraw from it in maintaining growth and life is transpired, or given out into the air, chiefly from the leaves. It is very difficult to measure accurately the transpiration from a single tree beyond the seedling stage, and infinitely more so to measure the transpiration from a forest. Blaney *et al.*[14] employed observations of stream flow to determine the water evaporated from the soil or consumed by canyon-bottom vegetation—"willows, tules, and kindred moist land growths"—in southern California.

The evapo-transpiration losses from Temescal Canyon during only 30 spring days they found to equal 12.9 inches of rainfall. The same author[15] estimated from stream-flow measurements in Coldwater Canyon that the transpiration losses from "alders, sycamores, bay, oak, and herbaceous growth" during the 6-month summer season of 1931 was 45 inches per acre. Evaporation was judged to be small as the water in the canyon bed is constantly cooler than the air. Inasmuch as the precipitation for the entire year is normally only about 30 inches, it is fortunate that the area of canyon-bottom vegetation is very small, and that the loss per acre of entire watershed is only 0.10 inch per mile of canyon. The transpiration losses just described are probably at or near the maximum for any forest type in the United States, and fully warrant the expedient, already adopted by such cities as San Bernardino, of piping water out of the stream channel before it can be consumed by the canyon-bottom forest. That the forest cover of the slopes and ridges in this region does not begin to make the same demands on soil moisture is very clear from its dwarfed development.

Data on transpiration rates for other American forest types are entirely lacking and these rates may only be inferred from general knowledge. Interception of precipitation, evaporation from the soil, and transpiration account for a very large part of the difference between the total precipitation over a watershed and the flow of the stream draining it. These differences have been earlier described for various parts of the country. Transpiration probably fully equals the other two factors combined in the hardwood forests of the humid eastern United States, but in the evergreen and chaparral forests East or West, may be subordinate to either.

INFLUENCE OF FOREST LITTER

Probably more important than any of the previously listed influences of the forest on run-off and stream flow is that exerted by litter.

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[13] Zon, R. "Forests and water in the light of scientific investigation." Final report, Nat. Waterways Com., Sen. Doc. no. 469, 62d Cong., 2d sess., 1912.

[14] Blaney, H. F., Taylor, C. A., and Young, A. A. "Rainfall penetration and consumptive use of water in the Santa Ana River valley and coastal plain." Calif. State Bul. no. 33. (Calif. Dept. Public Works, Div. Water Resources, in coop. U.S.Dept. Agr., Bu. Agri. Engineering) 1930.

[15] Blaney, H. F., Discussion of "Forests and Stream Flow." Proc. American Soc. of Civil Eng., December 1932.

Forest litter is the layer of fallen leaves or needles, of dead branches, down trunks, and other vegetable remains, which in varying depth is found under the crowns of trees and brush species in every temperate-zone forest. Through the gradual processes of decay and chemical change, and through the agency of animals which trample or otherwise disturb the surface of the ground, this litter is disintegrated into humus. Percolating water then carries the fine particles of humus, into the soil, where they are further broken down into nitrogenous products by bacteria and other organisms.

Forest litter exerts its influence in several ways. First and most important, it contributes to the humus content of the soil. It is an axiom in agriculture that humus, or organic matter, makes a heavy soil lighter, and a light soil heavier, by causing the soil particles to form crumbs. A crumb structure gives the maximum room for air and water, both vital to plant growth. How powerful an effect organic matter, although an unimportant fraction by weight in most soils, has on the water-holding capacity of the soil is illustrated by analysis in table 5, made by George Stewart of a granitic sand supporting ponderosa pine in Idaho. About 200 samples of the soil were taken to a depth of 4 inches, from openings, some large and some small, in a virgin stand. The condition of the vegetation refers to its value primarily as forage, and the deterioration is the result of grazing.

TABLE 5.—*Analysis of granitic sand soil under a ponderosa pine stand in Idaho*

Condition of vegetation	Organic matter[1]	Water-holding capacity[1]
	Percent	*Percent*
Good (nearly original condition)	10. 5	81
Intermediate (considerable deterioration)	4. 8	55
Poor (bad deterioration, soil usually gullied)	2. 4	44

[1] In percentage of dry weight of soil.

The ability of this soil to absorb water was nearly halved by its loss of a very small quantity of organic matter. Inasmuch as the soil of any watershed is the great underground reservoir replenished from time to time by precipitation, but at all times draining into the streams, its absorptive capacity is the great factor in sustained stream-flow. Humus and the decaying roots of plants enormously increase this capacity.

A second major influence of forest litter is its promotion of water percolation. If a soil is extremely shallow, or if precipitation is unable to percolate into it rapidly, run-off must take place over the surface from any but the lightest storms. If rain falls upon bare soil it becomes muddied and carries fine material in suspension downward into the minute interstices between the soil particles. How promptly and completely muddy water will plug these pores and slow the rate of percolation has been demonstrated by Lowdermilk.[16] After establishing, over a period consisting of parts of 7 days, the rate at which clear water percolated through columns of soil, he introduced sediment of less than 2 percent by weight into the water; within 6 hours the rate of percolation fell to 10 percent of what it had been. Moreover, the effect was permanent, as a return to the use of clear water did not restore the original rate. A good forest litter keeps the rain from becoming muddied when it hits the earth and so decreases run-off; in the absence of litter, surface run-off is enormously increased. When Lowdermilk applied artificial rain, at an average rate of 1 inch an hour, for several periods of ½ to 8 hours, to sloping tanks filled with typical California soils, he found that the surface run-off was from 3 to 16 times as great from bare soils from which the litter was burned as from those on which a litter cover was present.

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[16] Lowdermilk, W. C., "Influence of forest litter on run-off, percolation, and erosion." Jour. Forestry, April 1930.

An effect similar to that of litter cover in aiding percolation and in lessening the proportion of surface run-off is produced by low, permanent vegetation. Duley and Miller (op. cit.) state that whereas only 11.5 percent of 6 years' rainfall ran off over a sloping surface protected by a permanent grass sod, kept clipped, 49 percent ran off bare soil. Even where tilth of the bare soil was maintained by annual cultivation nearly 30 percent of the precipitation was carried off over the surface.

The superior physical condition and consequent permeability of forest soils has been demonstrated for Ohio Valley conditions by Auten.[17] Samples of the upper 9 inches of soil under several old-growth stands in oak-hickory and other hardwood types were found to be 13 percent lighter at oven dryness than equal volumes of soil from adjacent cultivated fields and a few pastures—indicating more pore space and better tilth. Although this difference in weight was later found to be confined to the upper 6 inches, the forest soil was still distinctly the more pervious to moisture at a depth of 8 inches. At a 3-inch depth 14 times as much water was absorbed per minute by the forest as the field soil, and at a 1-inch depth, over 50 times as much.

Auten points out that the favorable effect of the forest on the soils he studied is not entirely due to the litter, but is increased by the roots, which upon their death decay and leave the soil interpenetrated with tube-like cavities; also by the activities of burrowing worms, insects, and animals, which make the soil porous. A litter cover promotes these activities. Lowdermilk reported that earthworms appeared under the litter during the second year of his comparison of run-off from bare and litter-covered plots.

Secondary but sometimes important effects of litter upon run-off are produced by its absorption of moisture, its retardation of evaporation from the soil beneath, and its prevention of deep freezing. Investigations by the Forest Service and other agencies[18] have shown that litter from both the conifer and oak-chaparral types of California absorb about 1.8 times their own dry weight of moisture; freshly fallen pine litter in both the Lake States and the South, 1.5 times; conifer litter in the southern Appalachian Mountains, 3.4 times and hardwood litter, 4.6 times; and spruce-northern hardwood litter in New England up to 9 times its dry weight. The rainfall equivalent of moisture absorbed by the litter normally accumulating in this wide assortment of types ranges from a negligible quantity to nearly an inch, and within a single region, according to Alway and Harmer,[19] may be 9 times as much in a dense stand as in one opened by cutting. The Red Plains Experiment Station near Guthrie, Okla., found the litter on a post-oak area to have a water-absorption capacity of 16.7 tons per acre.

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[17] Auten, John T., "Porosity and water absorption of forest soils." Accepted for publication by Jour. Agr. Res., 1933.

[18] "Relation of forestry to the control of floods in the Mississippi Valley." House of Rep. Doc. No. 573. 70th Cong., 2d sess., 1929.

American data on the effect of a litter cover on evaporation from forest soils are singularly lacking, but European comparisons, quoted by Zon (op. cit.) of forests with and without litter, indicates that this natural forest mulch may reduce evaporation by 40 to 60 percent.

A litter cover materially retards both the rate and depth of freezing of the soil beneath. MacKinney (op. cit.) found that under a 2-inch litter in a Connecticut plantation of Norway and white pines, frost in 1926–27 was a month later in penetrating the soil at all, and final penetration only 60 percent as deep, as where the litter had been removed.

> The character of the frozen soil was influenced markedly by the litter. The soil on the bare plot froze solidly, and the air spaces were practically filled with ice. On the other hand the frozen soil beneath the litter cover was porous and loose, at no time being frozen too hard to allow the insertion of a shovel * * *. During winter rains and thaws, the water soaked into the soil of the litter-covered plot and percolated to lower depths. On the bare plot the water ran off at such times due to the nonporous character of the frozen soil.

SUMMARY OF INFLUENCES

Because forest that conserves snow and reduces evaporation of soil moisture must at the same time interrupt precipitation and transpire water drawn from the soil, its final effect on run-off can only be determined by the balance between these opposing influences. Whether this net effect is beneficial or harmful in any particular region is probably determined in part by the total amount of precipitation, but chiefly by the occurrence of precipitation as snow or rain, its distribution throughout the year or during only a part of it, and its arrival in light or heavy storms. American research to date, backed by a large body of observational evidence from all parts of the United States, justifies a strong belief that the forests of the country practically always benefit stream flow. A possible exception is the canyon-bottom vegetation of the drier regions, earlier described; even this may prove to have a net favorable effect in the checking of erosion. There can be no doubt at all that the net effect of forest litter, although it intercepts some precipitation and returns it into the air by evaporation, is extremely beneficial, since it reduces surface run-off and increases the water-storage capacity of the soil by increasing percolation at the same time that it shelters the soil moisture from evaporation.

From a careful consideration of each main region, it appears fairly evident that the climax forest—that type of forest which is best adapted to the climate and soil, and which nature, in the absence of fires, human interference, or epidemic of tree-killing insects and diseases, always tends to produce—was admirably adapted to promoting stream-flow conditions favorable to mankind. For example, the dense hardwood and hemlock forests of the southern Appalachian Mountains, where annual rainfall is heavy and floods result from a succession of storms rather than from a single very heavy storm, appear to constitute just the forest type to intercept the maximum of precipitation in the tree crowns and litter, and to reduce the flood crests by keeping part of the rain or melted snow from ever reaching the soil. Were such a forest capable of developing in southern California, where the comparatively light precipitation supplies a vital human need in the rich valleys, its draft on available moisture would be extremely serious. But the forest actually present on the hillsides is a dwarfed one, not transpiring appreciably at the season of heaviest rainfall, but producing a leaf litter having a profoundly favorable effect on percolation and water storage.

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[19] Alway, F. J., and Harmer, P. M., "Minnesota glacial soil studies: II. The forest floor on the Late Wisconsin Drift." Soil Science, 1927.

The natural climax forest of a region, although a valuable guide to what constitutes the best form and composition for a forest managed chiefly for its influence on run-off and stream flow, is probably not beyond improvement. When vastly greater research than has yet been attempted yields a knowledge of how much a given change in the character of a forest will improve the flow of streams, it is entirely possible that appropriate management will produce a forest with an even greater beneficial influence than the original. At the very least man has it somewhat in his power to control many of the natural catastrophes—fire and killing insects, for example—that ravaged some of the American forests long before Columbus' arrival, and which, as will be seen under a later heading, today have disastrous effects on stream flow.

HOW FOREST COVER INFLUENCES EROSION

Erosion, the removal of soil by water and wind, is taking place on all land areas. Where this occurs on land that has not been disturbed by man and is subject to no extraordinary climatic conditions the process may be termed "normal erosion." The intensity of normal erosion is determined chiefly by topography, geology, soils, climate (especially precipitation), and vegetative cover. Only rarely does it assume an intensity that involves serious damage to soil or to water flow or storage. In humid regions completely clothed with vegetation, as in a dense forest, natural processes are forming soil as rapidly as it is eroded and actual net loss, if any, is imperceptible. Surface run-off is ordinarily negligible, and consequently what erosion there may be is limited to light or dissolved particles of organic matter and practically no mineral soil is removed. Where the forest and other vegetative cover is definitely scant, as under semiarid conditions, there is still enough vegetation or debris to catch eroding soil and litter on slopes, retard run-off, and cause deposition of much of the eroded material already in motion. Even a light vegetative covering, if undisturbed, is sufficient to hold normal erosion to a negligible quantity. Only where the soil is unstable and easily erosible, as in the Badlands of the Dakotas, or on the outcrop of the Mancos and other similar shales, is normal erosion sufficiently rapid as to be perceptible.

On the other hand, when natural conditions are disturbed and nature's balance is upset by a reduction in the forest cover as a result of fire, logging, or overgrazing, or by marked changes in climatic conditions or other major causes, erosion in excess of normal is liable to occur. Furthermore, abnormal erosion, where it does occur, is an accelerating process. Its least conspicuous form is as sheet erosion, recognizable in the exposure of root crowns and roots of plants, in the lowered productivity of the site, in the accumulation of soil on slopes immediately above obstructions, and in the final disappearance of the mellow black surface soil. As the mellow surface soil is washed away, a more compact subsurface soil is generally exposed, less capable of absorbing rainfall and less resistant to erosion. Furthermore, decreased productivity may render it incapable of supporting as dense a stand of vegetation as formerly. There is thus less obstruction to run-off, less binding power in the soil, and less possibility of rebuilding the organic content. As sheet erosion becomes advanced the more rapid surface run-off concentrates and tends to cut small gullies. After hard rains on soils inadequately protected by vegetation the entire area may be cut by lines from the size of a pencil to gullies several inches deep. The smaller lines may be readily obliterated by creep of soil as it dries, but their original presence indicates a rapid soil wastage.

Finally, abnormal erosion assumes its most spectacular form as deep gullies on slopes and large straight-sided channels cut through flood plains. Its final effects are heavily soil-laden streams, especially when in flood; silted channels and reservoirs; mud rock flows from mountain stream courses; and deposits of inert sands and gravels on fertile bottom lands.

The control of erosion through retarding run-off is largely a function of the forest cover. This cover is responsible for improvement of soil structure, protection of the surface soil from beating rains, and, by intercepting run-off, reduction of the velocity and carrying power of the surface water. Lowdermilk has pointed out in his studies under controlled conditions that the run-off from soil surfaces protected by a litter cover alone was nearly clear. A summary of Lowdermilk's findings in table 6 shows strikingly the value of forest litter in reducing erosion on three important soil types. The weights of soil eroded from these plots, all of which had been litter covered for a year before half of them were burned bare, indicate that, on the average, removing the litter caused, respectively, 73, 160, and 1,196 times as much sediment to be eroded as was carried off from the protected soils. Studies in Arizona by C. K. Cooperrider, of the Southwestern Forest and Range Experiment Station, show that a vigorous herbaceous and shrub understory in the woodland type exerts a somewhat similar influence.

TABLE 6.—*Weights of soil eroded from plots protected by litter cover and plots burned bare on slopes of equal gradient and soils of three important types, under equal quantity and duration of artificial rainfall* [1]

Time of run (hours)	Average total rainfall	Sandy clay loam		Fine sandy loam		Clay loam	
		Litter covered	Bare	Litter covered	Bare	Litter covered	Bare
	Inches	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
½	7.86	0.05	18.6	2.00	234.0	0.51	285.4
1	15.44	.40	40.6	1.70	646.8	.60	593.7
1½	21.45	2.00	38.2	.95	28.1	.44	1,279.4
2	20.17	.35	89.6	.59	235.6	2.02	1,238.2
4	43.19	.45	35.4	2.48	19.0	.75	404.1
8	77.31	.50	48.6	1.07	235.6	.62	2,082.2
Average		.62	45.2	1.46	233.2	.82	980.5

[1] 10 runs made for each combination of time and condition.

Water erosion, however, is not the only form of erosion. Wind erosion, resulting in the formation of sand dunes, occurs in areas where trees or other vegetation are not able to hold light soils from transportation by high winds. Destructive dunes exist west of the Adirondack Mountains in New York, along the eastern shore of Lake Michigan and other Great Lakes, and in places along the Pacific, Atlantic, and Gulf coasts. Forests offer a possibility for the control of sand dunes in localities where climatic conditions are sufficiently humid to permit the establishment of a forest cover. In Europe many dune areas have been transformed by planting to good timber-producing forests, some of which served admirably for wood products in the World War. The establishment of trees or similar vegetation on dune areas breaks the force of the wind, and the litter cover, once complete, protects the soil from wind transportation.

CONSEQUENCES OF DISTURBING THE FOREST COVER

FIRE

Fire is the most wide-spread and one of the most destructive disturbances of the forest cover. Even the lightest fire consumes some of the inflammable materials on the ground—the litter in all its forms. The extent of destruction of these materials depends in the main upon their moisture content, and the humidity and other climatic factors at the time of the fire. In many forest types it is a common occurrence for the litter to be entirely consumed by a fire which does not do any spectacular damage to the standing trees. Thus is destroyed the enormously important protective soil covering, a chief factor in the forest's favorable influence on run-off and erosion. A fire which is hot enough to consume most of the litter ordinarily also destroys part of the humus in the top soil, thus damaging its loose, porous, granular structure, and making it less receptive to penetration of rain.

Bennett [20] in reporting on an unpublished finding of S. W. Phillips and I. T. Goddard at the Red Plains Erosion Experiment Station near Guthrie, Okla., in the spring of 1930, states that on two plots in post-oak timber—one on which the forest litter was burned, and the other, immediately alongside, on which the natural ground cover of leaves and twigs was left undisturbed—the run-off was measured during a period of almost continuous rainfall in May. Run-off from the unburned plot was clear and amounted to 250 gallons per acre, but that from the burned plot, having the same soil and slope, was muddy and attained a volume of 27,600 gallons per acre. The excess of run-off from the burned area over that from the unburned area plus the 16.7 tons per acre absorbed by the leaf-litter itself was approximately 90 tons per acre. The absorbed water went to replenish the underground soil water supply while that held by the litter was largely evaporated. From the burned plot an average of 0.15 ton of soil per acre per year was eroded, and from the unburned plot 0.01 ton.

In spruce forests of the East, particularly at high altitudes, fires have been very destructive. Here the mineral soil is shallow, and in places almost lacking, under a deep duff. Where this covering has been burned, the soil itself is practically destroyed. Studies by the Appalachian Forest Experiment Station on a 1924 burn in West Virginia indicated that spruce and hardwood litter from 12 to 18 inches deep was destroyed. In his report on the southern Appalachian region, which had a large influence in bringing about the purchase of national forests in the eastern United States region, Glenn[21] said of the Blackwater Basin in Virginia:

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[20] Bennett, H. H., Relation of Erosion to Vegetative Changes, pp. 385–415. Scientific Monthly, November 1932.

> All of the Blackwater Basin except its lower part has been thoroughly lumbered and then burned over, so that in many places the bare rocks are exposed and scarcely anything but briers and fire-scald cherries have since been able to take hold. It will be years before a commercial forest can be started and centuries before the magnificent hemlock, spruce, and pine that once covered it can grow again.

In the 20 years since this prediction was written, conditions have not materially changed on large areas, and the Forest Service has been obliged to plant part of the present Federal holdings.

In the chaparral type of California, a type characteristic of watersheds of critical importance to a large population, hot summer fires destroy the entire cover on thousands of acres every year, often leaving several inches of ash on steep slopes completely exposed to erosion. If the fall and winter precipitation comes as mild, well-sustained rains, studies of the California Forest Experiment Station have shown that a good cover of annuals will come in, and that these, together with sprouts from such crowns of shrubs as remain alive, may be sufficient to hold much of the soil in place. However, these rains are more apt to come as semitorrential downpours before an adequate vegetative cover has become reestablished and then great quantities of soil are washed from the slopes in the rapid unobstructed run-off.

Hoyt and Troxell[22] have compared the run-off of Fish Creek with that of Santa Anita Creek, neighboring watersheds, for the 7-year period from October 1917 to September 1924 when both were covered with forest and chaparral, and then for the 6-year period following a fire in the fall of 1924 which denuded the Fish Creek watershed. In the first year following the fire they found a 231 percent increase in run-off over their estimated normal of 1.07 inches and an increase of 1,700 percent in the maximum daily discharge resulting from the first four storms occurring after the fire. The peak discharge, which was ordinarily 2.5 times the maximum daily discharge prior to the fire, increased to 16.2 times on April 4, 1925.

Figure 1 indicates very clearly the enormously increased flood flows from Fish Creek and an adjoining burned watershed following heavy rains. In this graph the average daily rainfall at Mount Wilson and Santa Anita Ranger Station, in or near these watersheds, are contrasted with the combined daily run-off records of the United States Geological Survey for Fish and Sawpit Creeks (together with the flow in the Monrovia pipe line which comes from Sawpit Creek) for the spring of 1924, before the fire, and of 1925, after the fire.

During the second year after the fire Hoyt and Troxell found an increase of 26 percent above the estimated normal in the run-off from

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[21] Glenn, L. C., "Denudation and erosion in the southern Appalachian region and the Monongahela Basin." U.S. Geol. Sur., Prof. Paper No. 72., 1911.

[22] Hoyt, W. G., and Troxell, H. C., "Forests and Stream Flow," Proc. Amer. Soc. Civil Engin., pp. 1037-1066. Vol. 58, August 1932.

Fish Creek and during the 6-year period after the fire an average annual increase of 29 percent. Blaney (op. cit.), however, has attributed this increase to the destruction not of the chaparral, which constitutes 97 percent of the watershed, but of the canyon-bottom forest. Hoyt and Troxell's implied conclusion that in semiarid regions the land should be denuded of forest to increase stream flow cannot be accepted without first considering the certainty of greatly increased erosion and the usableness of the increased run-off.

Hoyt and Troxell themselves point out that under normal conditions erosion in the watersheds of Fish Creek and adjacent creeks was negligible, but that samples of water collected from these streams during 4 months immediately after the fire showed a total sand and ash content of 20 to 67 percent by volume and 6 to 40 percent by weight. They state also that in the first year after the fire the large deposit of silt from the burned-over area caused considerable damage to orchards, railroads, and highways adjacent to the mountains.

Cecil,[23] in discussing the usability of water from southern California watersheds, states:

> The prime requisite in water production is that the water must be usable. This factor is of greater importance than the quantity produced and is vastly more important than a minor increase in the sustained summer flow. Probably 95 percent of the water used for domestic and industrial purposes, outside the city of Los Angeles itself, is pumped (from underground reservoirs), as is also upward of 80 percent of that used for irrigation. * * * The replenishment of these underground reservoirs * * * is of paramount importance. In order that the water finding its way from the mountain areas onto the coastal plain may perform its maximum of use, as much of it as possible should percolate into the underground strata near the months of the canyons from which it issues. For years past, several communities, represented by the water companies supplying them, have spread the flood waters over the detrital cones by means of lateral ditches, increasing the wetted area and materially increasing percolation over that obtaining under natural conditions. The experience of these companies has proved beyond a doubt that, in order that water may be spread successfully and the maximum of percolation secured, it must be free of suspended matter. It is often necessary, during the first run-off of the season, to by-pass to the ocean a varying part of the flood flow. In the case of a watershed that has been run over by fire, the quantity that must be by-passed because of the silt load is many times as great as that under normal conditions.

Reports of the Forest Service indicate that before the 1924 fire on Fish, Sawpit, and Rogers Creeks practically all the run-off of these streams was either used for direct irrigation or went to replenish underground reservoirs as described by Cecil. After the fire, much of the run-off in 1925 was unusable because of erosion debris.

Under the semiarid conditions of southern California it ordinarily takes not less than 5 years for enough vegetation to be reestablished on burned watersheds to serve effectively in handling semitorrential rains. In instances where much of the productive top soil is washed off from the slopes as a result of hard rains in the first year, it will take considerably longer than 5 years to reestablish a closed canopy for the soil.

Farther north in California the foothills of the Sierra Nevada have suffered disastrously from fire. The effect of destruction of cover by fire in the transition between woodland and forest, in Madera County, is shown by experimental plots of the California Forest Experiment Station. In 1929, with 18 inches of the season's precipitation, 747 cubic feet of water per acre ran off the surface of burned plots and

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[23] Cecil, G. H. "Discussion of 'Forests and Streamflow.'" Proc. Amer. Soc. Civil Eng., December 1932.

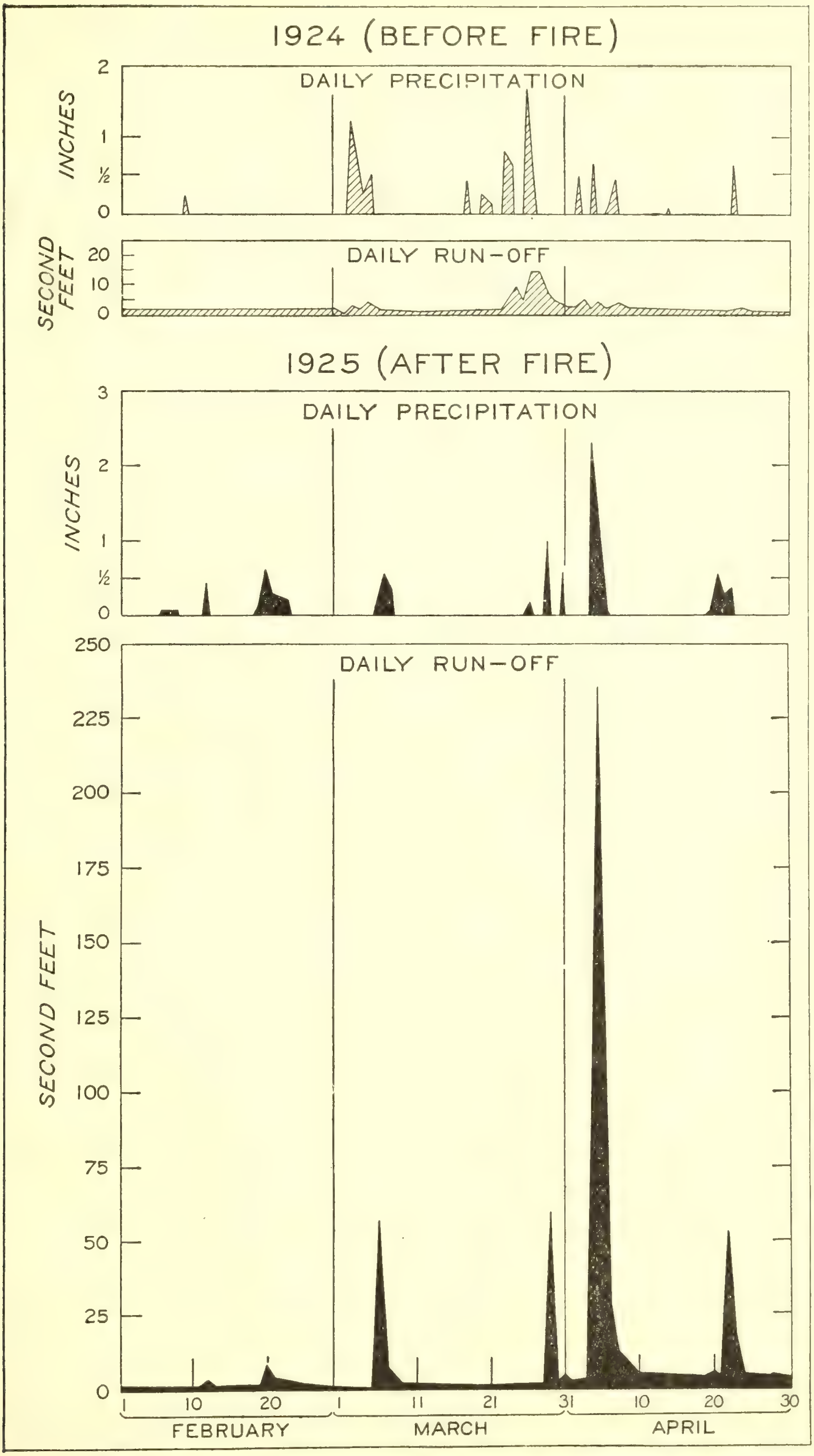

FIGURE 1.—Precipitation and run-off relationship in the Sawpit-Fish Creek drainage, Los Angeles County, Calif., before and after a forest fire occurring in the summer of 1924.

only 4 cubic feet from plots with woodland cover undisturbed. About 4 cubic yards per acre of soil were lost by erosion from the burned plots and only the barest trace from the unburned. Serious erosion is occurring over much of the foothill belt.

In 1929 a fire burned over a considerable portion of the Camas Creek watershed on the Challis National Forest in Idaho. It was evident in the next year that the fire had materially increased erosion. Extensive dry erosion (i. e., trickling of dry soil down steep slopes) and heavy sheet erosion had occurred. This process, begun immediately after the fire, was still going on in 1932.

Serious erosion was also evident on many of the older fire-swept areas. Such examples may be found around Lookout Mountain on the Idaho National Forest which was burned in 1919 or before, and on Sabe Mountain on the Bitterroot National Forest in Idaho, burned in 1910. The exposed roots of the snags and the elevated clumps of bear grass indicate that some 5 inches of soil has been eroded from the burned-over slopes since the 1910 fire.

A torrential rain on the Challis National Forest in 1932, for example, caused excessive run-off to originate on a 1931 burn, resulting in a heavy deposit of sand and debris in tributaries of Loon Creek, sufficient to destroy all possibility of fishing in the stream at least for a number of years. Run-off, the result of a heavy rain in 1932 on a 1931 burn in Richardson and Mann Creeks on the Idaho National Forest, caused deep gully erosion on the slopes and erosion of the stream channel to bedrock. The debris that was swept down these creeks into the Salmon River was sufficient to dam the swift-flowing Salmon River to a depth of 20 to 25 feet and a length of 450 feet, and to cause a new rapids to be formed in the river.

A marked effect of fire on stream flow has been evident under somewhat more humid conditions in the northern Rocky Mountains. In 1919 about 18 percent of the Clearwater River drainage, largely timbered, above Kamiah, Idaho, was burned over, but reclothed rapidly with brush and herbaceous vegetation. The Clearwater River gage records of the United States Geological Survey and data of the Weather Bureau for 10 years, 5 before and 5 after the fire, were analyzed by L. F. Watts, of the Northern Rocky Mountain Forest Experiment Station. These indicated a somewhat higher flow, in relation to precipitation, following the fire, but one much less equable. The average date of peak flow of the Clearwater was advanced by 14 days, in contrast with that of the Salmon River, the drainage of which had suffered much less from fire, which was only 2 days earlier. The average flow of the Clearwater on the peak days was 9.5 percent greater after 1919, in spite of the fact that the highest peak of the period occurred in 1917, as a result of exceptional rainfall in April and May. Furthermore, the April to June run-off increased from 66 percent of the total annual flow to 73.5 percent, and the July to September run-off decreased from 13 percent of the yearly flow to 9 percent. In other words, after the fire the spring flood was 11 percent greater than before the fire, and the summer run-off was 32 percent less. April to June flow is, of course, chiefly the result of surface run-off from melting snow, while July to September run-off results almost entirely from the slow drainage of ground water. The fires appeared to have increased the spring flood flow, but largely at the expense of summer flow.

LOGGING

Logging in the United States, which includes the removal of other products besides logs, is very variable in the proportion of the trees which it removes and its effects on run-off and erosion. Although a few small areas—mostly farm woodlands—are only culled of a few of the larger or choicer trees at any one time, the common commercial practice on the 10 million acres of forest annually cut over is a very close approach to clear cutting. Through a combination of cutting and fire about 850,000 acres of this are devastated each year—that is, left in such condition that they are incapable of producing another commercial crop of timber within a tree generation. The greater part of this area is almost devoid of standing trees, particularly in the softwood forest regions of the South and West, but some of the eastern hardwood land may have a considerable stand—worthless as a source of wood but very satisfactory as a watershed protection.

Logging alone, if neither preceded nor followed by fire, destroys a smaller proportion of the understory of young trees and shrubby species than of the main stand. However, important areas are still logged by high-powered machinery that drags logs over the ground and wipes out the lesser vegetation. It may even so churn the soil as nearly to obliterate the litter.

On a clear-cut area there is no longer appreciable interception of precipitation by tree crowns, and little high shade to retard snow melt or prevent evaporation from the soil. Temporarily, at least, there is small transpiration. There is, however, a very considerable shading of the ground by slash. This, in a good stand of southern pine, may cover 25 to 40 percent of the ground, and, in such conifer types as Douglas fir, western white pine, southern white cedar, or red spruce, may cover practically 100 percent. After a year or two, this slash itself may become powder dry, but it continues to exert some beneficial effect on evaporation from the soil. It may persist for as many as 10 to 20 years.

In many forest types, clear-cut areas are very abundantly invaded within a season or two by herbaceous plants. These at least serve to check erosion and start to rebuild the extremely important litter.

During a few years after logging, a sloping clear cut or severely cut area will unquestionably erode somewhat. The skid trails produced by power handling of logs in the California pine region, and logging elsewhere, have been found to start erosion.

It is impossible to generalize concerning the time which must elapse before reforestation restores conditions in cut-over land to the point where total run-off and seasonal run-off are essentially the same as in the preceding tree generation. Clear cutting has converted some forest types from all-aged to even-aged ones of probably permanently different character. An even-aged stand, for example, must permit of much less wind movement than an all-aged, once it has raised its canopy well above the ground. A sprout forest will, of course, restore the conditions more promptly than most seedling forests, because of the early vigorous growth.

This is borne out by the results of a watershed study at the Wagon Wheel Gap in the high mountains of Colorado,[24] in which the Forest

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[24] Bates, C. G., and Henry, A. J. Forest and Stream Flow Experiments at Wagon Wheel Gap, Colo. Final report. Mo. Weather Rev. Suppl. 30. 1928.

Service and the Weather Bureau cooperated. Here for 9 years, 1910 to 1919, stream flow from two adjacent watersheds was measured under undisturbed conditions; then the forest on one watershed was cut. As the forest was mostly aspen, sprouts of this species took possession of the area in the following year, so that the only real result of the cutting was the removal of the conifers which previous to the cutting were dominant on about a fourth of the area. Despite the fact that the forest cover was so promptly replaced by sprouts, the total yearly run-off was increased by about 15 percent and the summer run-off by about 10 percent. Flood crests were advanced about 3 days and the maximum height of crest averaged 64 percent greater in the cut-over area than in the undisturbed watershed. As previous to logging the height of crest from the cut-over area exceeded the undisturbed area by 6 percent, the net increase amounted to 58 percent. The silt load of the stream after logging increased seven and one half times.

OVERGRAZING

FOREST RANGES

Overgrazing on forest lands of the West was without doubt much more wide-spread 25 to 40 years ago than at present. However, serious depletion of the herbaceous and shrubby vegetation under the trees of the forest or in the openings within the forest—the result of past or present overgrazing—still prevails on enormous areas of forest land. The worst of it occurs in the semiarid regions.

If not utilized too closely, the forage produced each year by herbs and shrubs on forested lands is rather well maintained except in the occasional drought year. Investigations of the Forest Service clearly indicate that perennial herbaceous plants, principally grasses, were once the chief forage on most forest ranges, and this is still true except where these plants have been depleted. Studies also show that where trees do not grow in sufficiently dense stand to form a closed canopy, such as the woodland type, and also in openings in the denser forests, these perennial herbaceous plants if still present, are the chief erosion-control agent.

Overgrazing disturbs the forest cover chiefly in two ways: first, by consuming more of the herbage of the more palatable plants than they can withstand, and, second, by increased trampling. Under such overutilization, the palatable forage plants are grazed closer and closer, and their vigor is sapped. As these plants produce less forage and their stand is thinned, the less valuable plants are grazed more severely until they, too, are thinned. Studies by the Forest Service show that there are many areas now producing not more than 20 to 30 percent of the forage of which they once were capable, and under such conditions erosion is usually severe.

Conditions in central Utah as a result of past abuse illustrate this depletion. Good stands of wheatgrass and bromegrass in the openings of the aspen and subalpine forest types of the higher mountains were once capable of supporting a cow for a month on less than 2 acres. Remnant areas indicate that soils were deep and rich. Overgrazing depleted the open areas until they supported chiefly annual grasses and weeds, of which 10 acres or more are required to furnish a cow feed for a month. With such an inadequate protective cover several inches of topsoil has been eroded away over extensive areas.

Forsling [25] has pointed out that depletion of forage is accompanied by severe soil losses without any material gain in the total water obtainable from watersheds in this region. He studied conditions on two subalpine watersheds of about 10 acres each at the head of Ephraim Canyon, Utah. On watershed A, a 16 percent cover, mainly of annuals, was maintained from 1915 to 1920, but was improved gradually until in 1924 it reached 40 percent, made up chiefly of perennial grasses and weeds. In this condition it was maintained through the 6-year period 1924 to 1929. On watershed B, used as a check, a 40 percent cover, largely of perennial grasses and weeds, was maintained for the full period 1915 to 1929. Table 7 presents the comparative data from these two watersheds.

TABLE 7.—*Comparison of surface run-off and sediment removed from two watersheds under different densities of vegetative cover*

Period and watershed	Vegetative cover	Total rainfall [1]	Total surface run-off	Run-off per inch of rainfall	Sediment removed per acre	Sediment per inch of rainfall
	Percent	*Inches*	*Inches*	*Inch*	*Cu. ft.*	*Cu. ft.*
1915–20:						
Watershed A	16	30. 45	1. 5084	0. 0495	802. 9	26. 37
Watershed B	40	32. 01	. 2529	. 0079	148. 0	4. 62
Difference				. 0416		21. 75
1921–23:						
Watershed A	16–40	17. 20	. 7618	. 0443	315. 1	18. 32
Watershed B	40	17. 43	. 2153	. 0124	111. 9	6. 42
Difference				. 0319		11. 90
1924–29:						
Watershed A	40	25. 21	. 4914	. 0195	114. 9	4. 56
Watershed B	40	25. 96	. 2271	. 0087	46. 4	1. 79
Difference				. 0108		2. 77

[1] All storms coming as rain, or rain with snow and hail, and exclusive of storms that were snow only.

It is significant that the difference in surface run-off in summer rains between the two watersheds is 75 percent less after watershed A reached a reasonably good vegetative condition. It is excessive run-off from summer rainstorms that causes the destructive floods in this locality. In both periods the records available indicate that total surface run-off from summer rains amounted to less than one twentieth of the total annual surface run-off from the watersheds. Annual soil losses from watershed A in its depleted condition were over 8 tons per acre, nearly 85 percent of which was the result of summer rains. Approximately 133.8 cubic feet of soil per acre were removed annually from watershed A in the 1915–20 period and only 19.2 cubic feet per acre per year in the 1924–29 period. The difference in sediment removed between the watersheds was strikingly reduced following the improvement in vegetative cover—87 percent between the first and last periods.

Destructive floods have occurred in Utah in the last 10 years in the thickly populated area near Salt Lake. Studies made by Prof. Reed W. Bailey [26] of the Utah Agricultural College, in cooperation with the Intermountain Forest and Range Experiment Station and the Utah State Land Board, have shown that the 75-foot or deeper channel cutting and the enormous amounts of waste debris deposited by these recent floods were far in excess of any earlier flood action in that locality since the geologic Lake Bonneville ceased to exist some 30,000 or more years ago.

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[25] Forsling, C. L. A Study of the Influence of Herbaceous Plant Cover on Surface Run-off and Soil Erosion in Relation to Grazing on the Wasatch Plateau in Utah. U.S.Dept.Agr.Tech.Bul. 220. 1931.

[26] Bailey, Reed W. Statement in hearings before the House Committee on the Public Lands on H.R. 11816, 72d Cong., 1st sess. 1932.

After the floods of 1930 the governor's special flood commission established the fact that the heavily silt laden flood waters had collected chiefly on small areas of private land at the heads of the drainages where the vegetative cover had been destroyed or seriously depleted by overgrazing, fire, and to some extent by logging. These areas are badly gullied and the surface soil has been stripped away through sheet erosion. Slopes, too steep for grazing, that at intermediate elevations make up the greater part of the mountain face, bear a substantial brush or forest cover. No gullies originated on these densely vegetated slopes, where the thick litter cover and the large humus content in the surface soil permitted effective penetration of water and restrained the surface flow sufficiently to prevent undue soil or water losses.

There are in the West large areas of coarse readily erosible granitic soil. This is especially true of the Boise River drainage of southwestern Idaho where the underlying granite easily disintegrates, crumbling to coarse sand and fine gravel which combined make up 80 percent or more of the total soil mass. These soils are so extremely loose that where the plant cover becomes scarce the soil is readily swept off as sheet erosion. In the subalpine forest zone 4 to 8 inches of the black surface soil has been removed, and at lower elevations practically all the surface soil has been lost. Heavy run-off quickly causes the formation of gullies from a few inches to several feet deep. Loose soil on the edges of the gullies soon crumbles, and within a year or two after being formed many of the smaller gullies have so smoothed over as to appear to be healing when actually they are not.

Past overgrazing on practically all of the open areas within the forest and on some timbered areas of the Boise River watershed is known to have greatly reduced the protecting vegetative cover and trampling of these inadequately protected soils has often set in motion a downhill movement of the soil which is greatly accelerated by run-off from torrential rains.

Of nearly 350,000 acres examined by the Forest Service, more than 80 percent is in timber and heavy brush, which occupies all the north and parts of the south slopes. Fifty-six percent of the timber or brush areas subject to grazing has suffered sheet erosion, and 9 percent additional has suffered gully erosion as the result of overgrazing. Of the 53,000 acres of timber and brush areas too dense or on too steep slopes to permit grazing, only 14 percent had suffered sheet erosion and but 2 percent additional light gully erosion.

In contrast to these heavily grazed areas on the Boise watershed, only about 5 to 10 percent of similar locations and exposures on the game preserve on the nearby Payette drainage, subjected for many years only to light grazing, have lost the top layer of black soil. Beneath 1 to 3 inches of litter in open areas and 1 to 6 inches in the dense timber, the preserved soils contain 4 to 11 percent organic matter. This compares with 1 to 2 percent on the raw eroded soils, on which there is no measurable depth of litter.

WOODLAND PASTURES

In pastured farm woodlands of the Middle West, studies by the Central States Forest Experiment Station show that overgrazing results in the destruction of the sprouts of hardwood timber species, and that trampling of the livestock tends to destroy the litter and compact the soil, making it less receptive of precipitation and subject to erosion. Under extreme use, such as occurs in the Corn Belt where many farm woodlands are used as much for shade as for the feed they produce, practically the entire understory of vegetation and the litter covering the soil has been destroyed. When such a situation has developed the topsoil is invariably lost. Bates and Zeasman [27] have shown, on comparable soils, that, from a plot in pastured oak woodland with a slope of 38 percent, 13 percent of the rain ran off, while from a dense unpastured oak forest with a slope of 42 percent only 0.2 percent ran off, and only 2 percent from open unpastured oak woods with a slope of 49 percent ran off.

Auten (op. cit.) has shown in his studies of soil conditions in grazed and ungrazed woods in Ohio that the top 9 inches of soil in the grazed areas averaged 15 percent heavier than similar topsoil from ungrazed woods. This increase in density is a reflection of the greatly reduced capacity of the grazed soils to absorb water.

The work of Stewart [28] reveals the same tendency in New York State for long-continued grazing use to reduce permeability and water storage of soils.

SMELTERS

Fumes from smelters and other industrial plants may completely destroy or injure forest and other vegetation. Destruction by smelter fumes is found near Ducktown, Tenn., Kennett, Calif., Anaconda and Butte, Mont., and in the vicinity of a number of other smelters located within forested areas. Large areas around them demonstrate to a superlative degree the debt mankind owes to vegetation for its influence on surface run-off and erosion and the price we must pay when we destroy it. At Ducktown, an area of from 10 to 12 square miles around the smelters has become denuded of natural vegetation with the exception of occasional clumps of sage grass and wild smilax. Bordering this barren region is one varying from 1 to 5 miles in width, covered with sage grass, vines, and a few stunted shrubs and small trees, the latter often with dead tops. Beyond this border of almost treeless vegetation the country is not heavily wooded for some distance, the growth being unthrifty and trees with dead or dying tops being numerous.

Glenn (op. cit.) states that the annual rainfall in the region is 50 to 60 inches, and often torrential, so that during the downpours soil surfaces almost literally melt away. The wasted soil accumulates along the stream courses. He states further:

> On Potato Creek this waste has been accumulating for a number of years at the rate of a foot or more each year, and has been built into a flood plain from 100 to 300 yards wide, in which telephone poles have been buried almost to their cross arms and highway bridges, roadbeds, and trestles have either been buried by the debris or have been carried away by floods. . . . The normal flow of Potato Creek is said to be only about half as large as it used to be, and there can

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[27] Bates, C. G., and Zeasman, O. R. Soil Erosion, Wisc. Agric. Expt. Sta. Res. Bul. 99. 1930.

[28] Stewart, G. R. "A study of soil changes associated with the transition from fertile hardwood forest land to pasture types of decreasing fertility." Ecological Monographs, January 1933.

be no question that a much larger part of the rainfall now finds its way immediately into this stream and is carried off in floods, leaving a much smaller part to soak into the ground to supply the wells, springs, and streams during periods of dry weather.

Near Kennett, Calif., all vegetation has been destroyed on an area upward of 67,000 acres and partial destruction has occurred on 86,000 acres additional. Without the protecting vegetative cover, the surface soil of the denuded portions was soon washed off, exposing an inert subsoil which continues to wash and gully at a rapid rate. Munns[29] estimated a total of more than 35 million cubic yards had been removed from the Kennett area in 10 to 15 years. Conditions are very similar in other smelter areas.

CLEARING FOR AGRICULTURE

Hundreds of millions of acres once in forest have been cleared for crop production. This was a natural process in the settlement of the United States. At the time many were cleared little was known of the productive capacity or the erosiveness of the soils, and it is natural that many areas have later proven to be unsuited for permanent agricultural use. In the section of this report entitled "Agricultural Land Available for Forestry", the Bureau of Agricultural Economics estimated that today there are over 50 million acres of cleared land, which, abandoned or idle, are available for reforestation. Of these probably 11 million will require artificial reforestation. Present trends indicate an additional abandonment of some 25 or 30 million acres of potential forest land in the next 20 years.

These areas, abandoned or in process of abandonment, have largely passed such usefulness as they had for crop production. Many owe their abandonment to loss of productivity through erosion of the fertile topsoils and in some instances of large amounts of the subsoil. They are found most often in hilly and mountain regions, in regions of more level topography but having soils which erode with extreme ease, and in regions where the soils do not erode readily, but where the topsoil is so shallow and the subsoil so unproductive that the loss of a few inches of soil by erosion renders them practically worthless. These lands are widely distributed east of the Great Plains, but are found in parts of the West as well.

Through the adoption of contour plowing, terracing, crop rotation, and other suitable methods of cultivation doubtless much of the slightly eroding agricultural land can remain in crop production or in pastures. Such land is beyond the scope of this report. On most of the 50 million acres of abandoned lands, however, the loss of soil productivity has reached such proportions that cropping methods cannot be expected to overcome the active erosion and hazards of agricultural production. As Bennett[30] has stated:

> When the mellow topsoil is gone, with its valuable humus and nitrogen, less productive, less permeable, less absorptive, and more intractable material is exposed in its place. As a rule this exposed material is the "raw" subsoil, which must be loosened, aerated, and supplied with the needed humus to put it into the condition best suited to plant growth. This rebuilding of the surface soil requires time, work, and money. In most places this exposed material is heavier than

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[29] Munns, E. N. Erosion and Flood Problems in California. Calif. State Bd. Forestry Rpt. to the Legislature 1921 on Sen. Con. Res. 27. 1923.

[30] Bennett, H. H. "Part I. Some Aspects of the Wastage Caused by Soil Erosion." Pp. 1–3. Dept. Agr. Circ. 33, "Soil Erosion a National Menace." (H. H. Bennett and W. R. Chapline) 1928.

> the original soil, is stiffer, more difficult to plow, less penetrable to plant roots, less absorptive of rainfall, and less retentive of that which is absorbed, and apparently its plant-food elements frequently have not been converted into available plant nutrients to anything like the degree that obtains in the displaced surface soil. . . . Such raw material must be given more intensive tillage in order to unlock its contained plant food, and on much of it lime and organic manures will be needed in order to reduce its stiffness sufficiently to make it amenable to efficient cultivation, to the establishment of a desirable seed-bed tilth. It bakes easier and, as a consequence, crops growing on it are less resistant to dry seasons, because of rapid evaporation from the hardened surface, and the many cracks that form deep into the subsoil to enlarge the area exposed to direct evaporation. Crops also suffer more in wet seasons because the material becomes more soggy or water-logged than did the original soil. On much of it both fertilizer and lime will be required for satisfactory yields.
>
> While these difficulties of tillage and the lowered productivity are being attended to by the farmer in those fields not yet abandoned, the unprotected fields continue to wash. Unfortunately the farmers in many localities are doing little or nothing to stop the wastage and much to accentuate it.

Even on moderate slopes the soil losses from the cultivated fields on certain soil types, under unfavorable climatic conditions, are enormous. Forest Service studies at Holly Springs, Miss., in the loessial-soil belt, show that a single torrential rain falling on a cornfield having a 10 per cent slope washed soil from a study plot at the rate of 23 tons per acre. Preliminary results show that under such conditions only 2 to 3 years are required to wash away 1 inch of topsoil. These data, substantiated by observations, indicate that the cultivable life of these upland soils ranges from 5 to 20 years. Yet the serious danger of erosion from the cultivation of fields of slight slope in this region which have readily erosible soils is not so generally recognized and many such fields are being cleared and plowed to take the place of other fields which have lost their productivity. Bennett points out (op. cit.) that "some soils can not be cultivated without steady decline due to erosion, even where the slope does not exceed 1 or 2 percent. The Knox silt loam, for example, is such a soil. On this soil erosion goes on in all tilled fields where there is any slope whatever."

The high run-off from slight slopes is further shown by Duley and Hays[31] in their studies in Kansas. They found run-off increased rapidly as the slope increased from 0 to 3 percent grade. Over 63 percent ran off with a 2 percent grade in their experimental tank. The increase in run-off was then very slight for each 1 percent of increase in slope, reaching about 86 percent with a slope of 20 percent grade. Erosion, on the other hand, increased gradually until the slope was about 4 percent; then the increase was found to be more rapid up to about 7 or 8 percent, after which there was a still greater increase in the rate at which the soil was removed from the plots.

If level agricultural land were scarce in the United States, and there were a great need to increase crop production, very intensive farm management could unquestionably be applied to rather steep slopes to meet the situation. Under existing circumstances, however, it seems likely that clearing new ground on slopes of over 10 to 15 percent is destined eventually to swell the area of abandoned land and add to the problem of reclaiming gullied land by reforestation.

The process of planting trees on actively eroded land is not simple. Preliminary measures, in the form of temporary terracing, "plowing in" of gullies, planting vines and herbaceous plants, will often be needed where the brush and forest vegetation do not naturally reclothe the area quickly enough to check the erosion. Considerable research on such methods is needed, and on the most effective type of forest to establish on the depleted soils, now incapable in many instances of maintaining the original forest cover.

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[31] Duley, F. L., and Hays, O. E. "The Effect of the Degree of Slope on Run-off and Soil Erosion." Jour. Agr. Research, vol. 45, no. 6: 349–360. 1932.

WATERSHED-PROTECTION FORESTS IN OTHER COUNTRIES

In many countries "protection forests" are defined by law. They are forests the main object of which is to help to prevent avalanches and snowslides; check or reduce soil erosion; retard snow melt; preserve favorable conditions of run-off; stabilize shifting sands; protect other forests or property from wind, or contribute to the national defense. In short, the definition embraces all the many indirect benefits which the forest exerts upon water, soil, and climate.

Disastrous floods, silting of navigable channels, and destructive soil erosion gave impetus to the development of forest policies in numerous countries during the nineteenth century. It was readily recognized that these evils were greatly aggravated by denudation of forest lands in the mountains and along the streams. In Europe policies of alienating public forests, which had been adopted following the French Revolution, were halted. Instead, the public began to extend its ownership of forest lands, largely in the mountains, for the purpose of restoring and protecting the forest cover.

At the same time, governments began to impose restrictions upon the management of privately owned forests, where their preservation was deemed essential for protecting soil and water. As the years have passed, more and more countries have adopted such restrictions, until now the list includes practically all the countries of Europe, as well as Japan and a few others.

The scope of these restrictions varies widely, but in general the laws require that classified protection forests, regardless of ownership, be handled in such a manner that the forest cover will be maintained. Clearing of the land is usually prohibited, and timber cutting and grazing are generally subject to a greater or less degree of supervision by public authorities. The reforestation of denuded land and construction of engineering works to check or prevent erosion or control torrents are commonly provided for, partly or wholly at public expense. In Switzerland, for instance, more than $57,000,000 was spent on stream control works between 1862 and 1923. Nearly one half of this cost was borne by the Federal Government, and most of the remainder by the cantonal governments. Similar policies have been pursued by France, Italy, Austria, and Japan, as well as by other countries. Either by cash payments or by reduction in taxes, many of the countries reimburse the land owners, at least partially, for any loss in income which they may suffer as a result of the restrictions.

In case an owner is unwilling to retain his forest and manage it in the manner prescribed, it is commonly provided that the public shall buy him out. France and several other countries have a definite policy of acquiring private forests and denuded land in mountain districts, for the purpose of safeguarding protective values. Within the last few years very large-scale programs of public acquisition and reforestation, mainly of protection forests, have been under consideration in a number of countries. Shortly before her recent revolution, Spain appropriated $19,000,000 for this purpose. France has been considering an even larger program.

Public forests that have protective value are, of course, almost universally managed so as to preserve and increase their protective effect. Soviet Russia has excepted forests that lie along or on the headwaters of important streams from the present policy of liquidation of timber values which is said to be applied to other forests. Just as in the United States, a large proportion of the public forest area in many countries, particularly that belonging to provincial or national governments, is in mountain regions and consequently of high protective value. The less accessible mountain forests naturally were the last to be sought by private owners. This is less true of the communal forests, which are generally located fairly close to settlements. Forests belonging to mountain communes, however, such as many of those in Switzerland, Austria, France, and Spain, also have high protective value and are managed accordingly, generally under the supervision of the national governments.

More detailed information on the foreign legislation dealing with protection forests is given in the section on "Public Regulation of Private Forests."

CLASSIFICATION OF WATERSHED PROTECTION INFLUENCE OF FORESTS OF THE UNITED STATES

With a view to determining the relative importance of forests in the regulation of stream flow, in water supplies, in erosion control, or in influencing other watershed values, the forest areas of the United States have been classified into three groups: (1) Those of major influence; (2) those of moderate influence; and (3) those of slight to no influence. It is recognized that adequate scientific data and results are not available for an absolute classification. In classifying the forest lands, however, the possible application of such research data as are available has been considered for all areas, and these data have been supplemented by field observations and study of all available records. In order that the interpretations would be most useful, general observational surveys were supplemented by specific examination of representative areas. The classifications represent the best combined judgment that the Forest Service could bring to bear on them.

Forests considered as of major influence included those occurring on steep slopes subject to heavy or concentrated rainfall; on areas with excessive and rapid snow melt; and on areas having unusually erosible soils, where in the absence of the forest cover serious damage would be apt to be done to soil or other values of the watershed itself, or to land, improvements, navigation, or other values. In a number of localities, particularly in the West, where the demand for water is unusually great and where because of scant rainfall it is necessary to conserve as much of the stream run-off as possible, the forest cover, even though far from a complete canopy, has been classed as of major influence. These forests include many areas of the woodland type, where disturbance of the forest cover has caused or would cause abnormal erosion and endanger water conservation through the excessive silting of reservoirs, or of gravel beds into which run-off is sunk for underground storage and later pumping, as in southern California.

Forests considered as of moderate influence include those occurring on moderate slopes, on areas of moderate or scant rainfalls, on soils which do not erode readily, and on areas where the forest cover quickly reclothes the land in case fire, lumbering, or other cause depletes the cover.

Forests considered as of slight to no influence include those areas where it appears that the forest exerts only a poorly defined or very indirect influence upon streams, water supplies, or erosion. Forest areas classified as slight include those more or less level areas occurring on old lava flows, or on deep sandy soils through which precipitation readily percolates, and from which erosion is very slight. Likewise forests occurring on poorly-drained and nearly level areas have been considered as of slight influence.

In order to indicate these broad classes on the maps accompanying the report it has been necessary to include with a larger area of another classification many small areas not strictly classifiable as shown. As intensive a classification as possible was made, however, and is shown diagramatically on the regional maps whenever the areas were large enough to be recognized.

DRAINAGE BASINS OF THE UNITED STATES

Forest conditions throughout the United States differ so widely, their influence on watershed problems is so varied, and the importance and character of the watershed problems so varied, that for purposes of even somewhat detailed description the country has been divided into drainage regions. In part these are purely geographical, in part they represent large drainage basins. Figure 2 indicates the division of the United States into these regions.

For each of the drainage regions the influence of the forest is represented. The present condition of the forest, and its effectiveness in exerting the influence of which it is capable are also indicated.

NORTHEASTERN DRAINAGES

The northeastern drainages as here covered include all those streams which flow into the Atlantic Ocean north of the Potomac River, excepting tributaries of the St. Lawrence River. In considerable part they include the two regions discussed elsewhere as the New England and the Middle Atlantic States (fig. 3).

CLIMATE AND PHYSIOGRAPHY

Compared with many portions of the United States where watershed and stream flow problems are also acute, the northeastern drainages receive abundant rainfall—from 30 to 50 inches annually at most points, and up to 75 inches on some of the higher mountains. There are no conspicuously wet or dry seasons; the average monthly rainfall during the wettest months of the year is rarely more than double that of the driest months.

In spite of the normally high and equably distributed rainfall, however, deficiencies and irregularities in rainfall are by no means uncommon. In 1930 for example, the southern and central portions of the

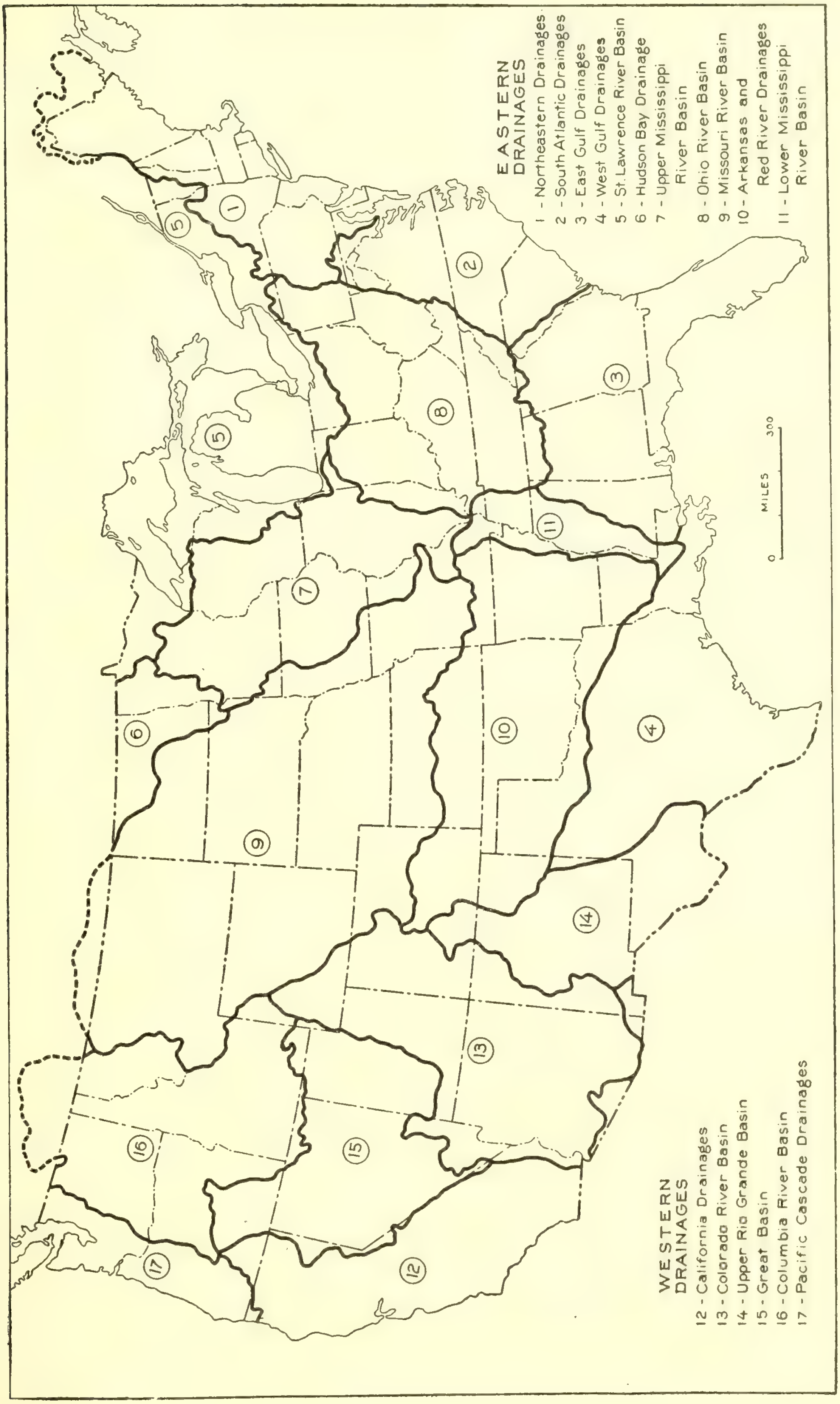
EASTERN DRAINAGES
1 - Northeastern Drainages
2 - South Atlantic Drainages
3 - East Gulf Drainages
4 - West Gulf Drainages
5 - St. Lawrence River Basin
6 - Hudson Bay Drainage
7 - Upper Mississippi River Basin
8 - Ohio River Basin
9 - Missouri River Basin
10 - Arkansas and Red River Drainages
11 - Lower Mississippi River Basin
WESTERN DRAINAGES
12 - California Drainages
13 - Colorado River Basin
14 - Upper Rio Grande Basin
15 - Great Basin
16 - Columbia River Basin
17 - Pacific Cascade Drainages
0 MILES 300

FIGURE 2.—Major drainage basins of the United States.

region were visited by a drought of extraordinary length and severity. Maryland received only 56 percent of the normal rainfall in that year, Delaware 65 percent, and Pennsylvania 68 percent. Although this drought was a record one for the region as a whole, in central New England it was exceeded by the drought of 1929. Extremely heavy downpours in brief periods of time are also characteristic of the regional rainfall. The middle Atlantic coast, with its center in northeastern New Jersey, is particularly subject to very heavy precipitation; between 1843 and 1929 this region experienced 102 storms of 5-inch precipitation in 24 hours. Two storms during that period produced 15 inches of rain in 24 hours. Annual snowfall ranges from an average of 14 inches at the Delaware capes to 150 inches in the Adirondack Mountains of New York. It is from 50 to 100 inches throughout Maine, but in the southern part of the region reaches 50 inches only at the higher elevations. Snow lies on the ground for one to five months, depending on latitude and altitude.

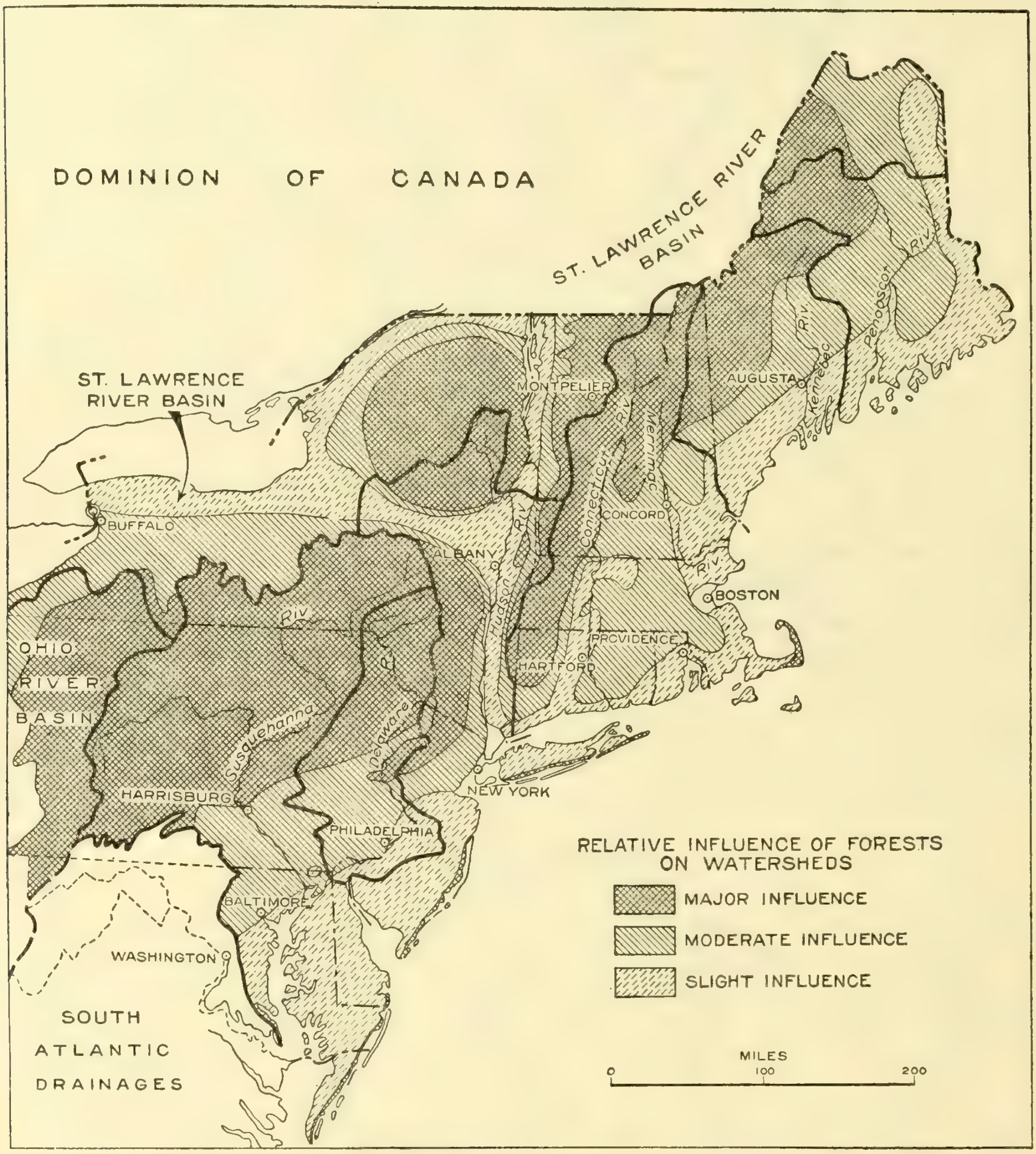
DOMINION OF CANADA
ST. LAWRENCE RIVER BASIN
ST. LAWRENCE RIVER BASIN
OHIO RIVER BASIN
SOUTH ATLANTIC DRAINAGES
MONTPELIER
AUGUSTA
CONCORD
BOSTON
PROVIDENCE
HARTFORD
ALBANY
BUFFALO
NEW YORK
HARRISBURG
PHILADELPHIA
BALTIMORE
WASHINGTON
Penobscot Riv.
Kennebec Riv.
Merrimac Riv.
Connecticut Riv.
Hudson Riv.
Delaware Riv.
Susquehanna Riv.
Riv.
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
MILES
0
100
200

FIGURE 3.—Northeastern drainages, and lower portion of St. Lawrence River Basin.

Elevations above sea level are less than 500 feet throughout the coastal plain and much of the adjacent piedmont province, and in the southeastern half of Maine. They exceed 3,000 feet in the Allegheny Mountains, 4,000 feet in the Catskills, 5,000 feet in the Adirondacks, and 6,000 feet in the White Mountains. Differences in elevation of 1,000 to 1,500 feet between ridges or plateau tops and the adjacent valleys are common.

Glacial soils are characteristic of the region as far south as northern Pennsylvania and New Jersey. These include considerable sandy areas. Sands are of course characteristic of the coastal-plain province from the tip of Cape Cod to the shores of Chesapeake Bay. On the whole, however, heavier soils predominate. The soil mantle becomes extremely thin at the higher elevations and there are some areas of practically bare rock, either outcrops or of glacial deposition.

WATERSHED AND STREAMFLOW PROBLEMS

There are five major watershed and streamflow problems in the region, in the solution of which the forests of the region may play an important role. These, in their order of importance, are urban water supplies, water power, navigation, erosion, and floods.

URBAN WATER SUPPLIES

The problem of obtaining adequate water supplies for municipal use—both for domestic and industrial purposes—has received much attention in the Northeast, because of heavy concentrations of population. The metropolitan districts of Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, and Maryland contain over 15 million people. Forty percent of the population of the last four of these States is concentrated about the cities of New York, Philadelphia, Baltimore, and Washington. The Regional Planning Federation of Philadelphia estimates the present consumption of water in Philadelphia and the surrounding territory to be 467 million gallons daily, and that of 50 years hence at 800 million gallons. More than half of this consumption is by industries. Using as a basis the per capita consumption of Philadelphia, 132 gallons daily, water requirements for the metropolitan centers of the region may be estimated in excess of 2 billion gallons daily.

In the Northeast much of the water for urban consumption comes from surface streams. The larger available rivers are for the most part rather heavily polluted, at least in the lower reaches, by mining, pulp, and industrial waste, and by the sewage of scores of communities. Although practically any polluted surface water may be so cleansed as to be clear, palatable, and normally safe, the consequences of a failure in the treating process are so serious, and public prejudice against the use of polluted streams is so great, that a clean raw water supply is preferred by most cities. Largely for this reason, the city of Boston is planning a dam and reservoir 60 miles from the city, and New York City obtains part of its present water supply from a reservoir located 92 miles away. New York City's investment in four dams, behind which 166 billion gallons of water may be stored, exceeds $66,000,000. The communities of northern New Jersey plan a high-level development costing about $45,000,000 exclusive of the distributing systems, and according to the Water Policy Commission of New Jersey even this huge project will not meet the needs of these communities beyond 1960. Philadelphia draws its water supplies from the Delaware and Schuylkill Rivers. Of the Schuylkill River the Regional Planning Federation of Philadelphia states: "It is doubtful if there is a river of similar size in the United States, undeveloped by storage, which is utilized more intensively and completely for water supplies than the Schuylkill."

Even underground water supplies have felt the heavy drain of human use. The coast resorts of southern New Jersey, for example, which obtain municipal water supplies largely from deep wells, have found the ground water table seriously lowered in recent years, and face the threat of an invasion of salt water from the ocean. The draught on the underground water supplies of Camden and the adjacent territory in New Jersey is said to be increasing at the rate of about 3 percent a year.

The droughts of 1929 and 1930 emphasized the seriousness of the municipal water-supply problems in the Northeast. In 1929 several communities near Boston, having independent water supplies normally adequate to their needs, were obliged to tap the already depleted metropolitan district water system with temporary pipe hastily laid on the surface of the ground. An official of the Maryland State Department of Health said of the 1930 drought in his State:

> Few things have more seriously affected our lives, our health, or our peace of mind, than did the drought of 1930 * * *. Nevertheless, the results of the long-continued drought have not all been bad. Faced with a disastrous shortage, if not a complete lack of water, people in towns fed by public water supplies, and others in settlements or on farms drawing water from wells, springs, or cisterns, have been compelled to think and devise means of escape.

Equable streamflow for domestic and industrial use remains a major public problem of the northeastern United States.

WATER POWER

Water power has been extensively developed in the Northeast. It was the basis for the original manufacturing supremacy of New England. In Maine, 70 percent of all power for industries and public utilities is developed from streams. The horsepower developed by five plants recently constructed on a comparatively short stretch of the Connecticut River aggregates 350,000. In 1931 New York produced more power from her streams than any other State in the Union except California, and nearly twice as much as the State third in rank—North Carolina. At three points on the lower Susquehanna River are power plants with capacities of 158,000, 170,000, and 378,000 horsepower, respectively, and the electrical energy developed on the entire Susquehanna is about two thirds that which will be developed on the Colorado River at the Hoover Dam. According to the figures of the U.S. Geological Survey for January 1931, more than 30 percent of the Nation's water power is produced in the Northeast.

In the absence of a natural uniform flow, power plants must rely upon costly reservoirs or else resort to supplementary steam power. Streams from forested watersheds tend toward uniformity. Irregularity in stream flow made necessary the Conowingo Dam on the Susquehanna River in Maryland, which cost $52,000,000.

NAVIGATION

A third watershed and stream-flow problem of great local magnitude in the Northeast is the maintenance of navigation. The annual report of the Chief of Engineers, U.S. Army, shows that in 1929 commercial tonnage on the principal rivers of this region was considerably greater than that transported on the Mississippi River, from Minneapolis to New Orleans. In order to maintain a ship channel of proper depth in the Delaware River to the port of Philadelphia, the War Department between 1920 and 1931 spent $31,500,000, chiefly in dredging, and from Philadelphia to Trenton, an additional $800,000. Dredging the Schuylkill River at Philadelphia has cost the Federal Government $1,300,000 in the same period. The maintenance of these and other ship channels of the Northeast in the face of continued deposition of silt and similar material brought down by the streams, is closely related to the fourth major stream flow and watershed problem of the region.

EROSION

Soil erosion resulting from a rainfall of 35 or more inches a year, at times concentrated in very brief periods, depends on three main factors: Degree of slope, character of soil, and vegetative cover. Of the forested area on the northeastern drainages, 10 percent has been classified as very steep, 22 percent as steep, 15 percent as moderately steep, 40 percent as gently rolling, and 13 percent as level. The streams of northern New England are relatively free of silt and debris, showing that erosion is not particularly serious. It is more than a coincidence that even in the mountainous portions erosion is slight and percentage of forest cover high. In southern New England, Pennsylvania, and northern New Jersey erosion is prevalent. Here the soils are heavier, and there is a greater proportion of agricultural land.

Erosion is unquestionably most severe on agricultural lands exposed by plowing and clean cropping. Farm-land abandonment has been general throughout the northeastern States; only a single small county in one State—New Jersey—has escaped it. In Hamilton County, N.Y., there has been since 1900 a decrease of 78 percent in the area of cultivated land; in Cameron County, Pa., the decline is 63 percent; in Berkshire County, Mass., the decline is 60 percent. For the northeastern drainages as a whole the acreage of crop land abandoned in the past two decades amounts to over 10,000,000 acres. Some of these lands have developed a sod which is holding the soil in place. Many others lack cover, and are eroding seriously.

How much of the present decline is due to decreased fertility of farm land is not known, but the condition of some abandoned fields shows that erosion was at least partly responsible. Although shoestring gullies in abandoned fields on steep slopes are not uncommon in any State, sheet erosion is far more prevalent than gullying. In many parts of New England and New York, for example, the widespread occurrence of gravel and stones on the surface of fields is evidence that the finer soils have been removed by erosion following clean cultivation. Several thousand acres of formerly excellent agricultural land in northern New Jersey have gone entirely out of cultivation as a result of such erosion.

Clear cutting of the timber and burning of forest land exposed the soil, at least temporarily, to erosion. The more complete the exposure, the more nearly are conditions reduced to those existing on clean-tilled land.

Erosion is unquestionably responsible for the major part of the expenditure to maintain channels in the Delaware River, as has been previously described. Erosion has its effect on water storage, for municipal supplies and power. In 1915 the State forester of Maryland described as follows the results of erosion along the Patapsco River in his State:

> Between Relay and Alberton, a distance of 11.4 miles, there are 10 water-power developments, 8 of which are now in operation. Power for these plants is furnished by the Patapsco River, and its value for that purpose is measured by the evenness of flow and freedom from silt * * *. The steep slopes along the river that have been cultivated in years past have largely contributed to the accumulation of silt which has collected behind the dams built for storage purposes and has clogged the river channels, increasing the frequency of floods and carrying immense quantities of silt into the upper Patapsco near Baltimore, requiring the expenditure of large sums of money for dredging.

Another erosion problem of considerable local importance in the northeast is not created by water, but by wind. The shores of both the Atlantic Ocean and the sheltered bays behind sandy spits are used for recreation by enormous numbers of people. In places drifting sands have seriously interfered with this use. Efforts have been made to control the dunes on Cape Cod and at various other places along the coast, but individual effort has not been effective in the face of a problem common to many owners of shore properties. The need for studied and concerted effort is emphasized by the constant increase in number of the recreationists. Not less than 500 miles of coast line is involved in varying degree.

FLOODS

Low water during the summer in streams used for municipal supplies, for generation of power, and for navigation, is scarcely more of a problem in the region than is high water at other times of the year. Parts of the northeast have suffered very greatly from floods. The 1907 report of the Water Supply Commission of Pennsylvania stated that:

> Pennsylvania is one of the worst sufferers from floods among the eastern States * * *. It is not alone the large streams on which damage has been wrought, for many of the smaller streams overflow their banks with disastrous results, and in such cases the damage has been increased by the failure of dams or embankments, thus releasing the additional water into the already overflowing channel.

The North Branch of the Susquehanna River has repeatedly inundated the city of Wilkes-Barre, and the floods of 1902 and 1904 in this stream destroyed $1,300,000 worth of bridges alone, as well as millions of dollars worth of other property. According to a report made in 1931 by the New Jersey State Water Policy Commission, a repetition of the 1903 flood in the Passaic River would today cause a damage of over $42,000,000. Such floods in the Passaic may be expected only about once in 200 years, but a flood causing $1,000,000 worth of damage will occur on the average once every 5 years, and one causing over $2,500,000 damage every 10 years. The commission concluded that the values at stake in this watershed justify the expenditure of $93,000,000 on channel improvements. The New England flood of the fall of 1927 took 88 lives and caused damage of $30,000,000 in Vermont alone. The board of engineers studying the Vermont flood situation reported that it would cost at least $40,000,000 to prevent, by means of storage reservoirs, a repetition of the 1927 disaster.

FORESTS AND THE WATERSHEDS

Considering the importance to the northeastern States of their municipal water supplies, their water power, and their navigation, and the damages which they suffer periodically from floods and at all times from erosion, the condition of their watersheds with respect to control of run-off is obviously a matter of the greatest concern. The vegetative cover on these watersheds is the one factor in this condition which it appears to be within human power to control.

LOCATION OF THE FORESTS WITH RESPECT TO CRITICAL AREAS

Practically the entire region was once densely wooded. Some kind of forest still covers 54 percent of it. The forests are in general located on the steeper slopes at the headwaters of the streams, where there is every reason to believe that a cover of protective vegetation is most badly needed. Forests are, however, nearly absent from a few streams which flow for almost their entire length through agricultural land and which are important as sources of municipal supply. On one of the most critical watersheds of the entire region, from the standpoint of floods, the percentage of forest is rather low: this is the Passaic River watershed, with little over 50 percent in forest.

ORIGINAL AND PRESENT CHARACTER OF FORESTS AS AFFECTING EROSION AND STREAMFLOW

The original forests of the northeast, now practically gone, were composed of spruce and fir in the north and at the higher elevations further south; northern hardwoods, white pine, and hemlock at intermediate elevations; and mixed hardwoods, largely oak, or hardwoods and hard pines, at the lower elevations. The early cuttings, except when followed by fire, probably did little real damage to the forest.

Even at the height of the lumber industry large continuous areas of forest were not often cut clean, and removal of the logs from the woods with animals generally in winter, injured the remaining trees and young growth very much less than have the logging methods of many other forest regions. Unfortunately, fires have followed cutting on a great many areas, so that there are in the region as a whole about 10 million acres of forest land not now satisfactorily stocked to valueable tree species. These areas include grey birch, scrub oak, aspen-pin cherry, and similar forest types nearly worthless commercially. Probably the most conspicuous and important change wrought by cutting fires in the original forests has been a reduction in the proportion of softwoods. A second important result has been the conversion of great areas of originally all-aged forests to an even-aged condition.

Cutting in the spruce woods for pulp and lumber has unquestionably resulted in an inferior growth, but not often in the total destruction of the cover. Over considerable areas the spruce and balsam have been replaced by aspen, birch, and other hardwood species. Although probably not as effective as the conifers in building up a good vegetative cover and a heavy litter, these species are excellent soil binders. There are some areas where restocking, even with hardwoods, has not followed cutting and fire, and here and there in New England and New York are mountain tops which have been denuded of their very soil by severe fires and consequent erosion. On less thoroughly denuded areas the first cover to appear is scanty grass and herbs, followed by brush. The conversion to a good forest condition is extremely slow.

The white-pine forests have probably suffered more severely from cutting and fire than any other forest type in the region. When destroyed, the white pine often has difficulty in reestablishing itself in competition with inferior vegetation. Exposure of the soil during the slow return of the pine is less serious than it would be if the pine did not occur for the most part on sandy soil.

The northern hardwood forests are probably in better shape than any other forest type in the region. Fires are less prevalent than in the conifer or oak forests. Slash appears to decay more quickly after cutting, and the forest seems to be less inflammable at every stage of development. The hardwood leaf litter breaks down rapidly into humus. In the absence of fire, reproduction is excellent even following clean cutting. Repeated fires, or a single severe fire in slash, may reduce this type to aspen-pin cherry of no commercial value and too open to produce a deep leaf litter.

The oak forests have suffered from overcutting, fire, and the chestnut blight. A large portion of the oak type is today at least the third generation from the original forest, and because the second cutting generally took place before the trees had reached full seed-bearing size, the third growth is very largely sprouts. The blight has eliminated chestnut from the region, and although its place in most stands has been taken by other species, there are ridges and south slopes where a good forest cover has not yet developed. Where fires have been particularly frequent in this type, as in the anthracite-coal region of Pennsylvania, the forest has degenerated into scrub oak and grey birch thickets. The scrubby species are not only commercially worthless but render artificial rehabilitation—planting—of the site extremely difficult. In southern New Jersey the mixed oak and pine forests have been repeatedly cut for fuel wood on a short rotation. Because some of the hardwood stumps fail to sprout, and because periodic fires have tended to wipe out pine seedlings starting from windblown seed, the forest has become progressively more open and filled with underbrush.

OWNERSHIP

The farm woodlands which constitute a considerable part of the forests of the region are generally in better shape than the larger tracts owned by forest industries. Some of the loblolly-pine woodlots of the Eastern Shore of Maryland are particularly productive.

Substantial areas in State ownership, notably in New York and Pennsylvania, have received better-than-average fire protection for a good many years, and have been subject to little or no cutting. Their growing stock has steadily built up. Locally, a long-continued ebb in forest industries has brought about a similar condition on lands in all ownerships. It is probable that there is now more timber at or near merchantable size in northern New Jersey, for example, than at any time since the Civil War. Fire protection is unquestionably beginning to show its effects in most of the region.

Public ownership has been an unquestioned factor in the restoration of the forests of this region. Over 10 percent of the forest area is now publicly owned, and most States have an acquisition program of considerable magnitude. New York already possesses nearly 2½ million acres of forest land, and is actively buying another million. Pennsylvania has nearly 2 million acres in State forests and State game lands. Federal ownership in the White and Green Mountains of New England now covers more than half a million acres. These Federal forests have been established primarily because of their watershed value. It is particularly significant that many municipalities in this region own watershed forests. In every State communities have acquired part of the land from which they obtain water, and where these lands have required reforestation they have been planted. Some 350 communities in New York now possess municipal forests; New York City has the largest area on its Ashokan Reservoir drainage. Glens Falls has planted more than 2 million trees on the denuded land acquired as a city watershed. Cities and towns in Massachusetts own over 50,000 acres of watershed forests. Forty towns in Vermont possess municipal forests, largely for watershed protection. Newark, N.J., has a watershed forest of 35,000 acres. Private water companies own considerable acreage of forest land. Forests on municipal watersheds not only serve the local public by yielding good water, but they have returned revenues from the sale of forest products. Altogether in the region of northeastern drainages the public owns some 5½ million acres of forest, the greater part of which may be classed as protection forests.

CONCLUSIONS

The abundant rainfall and the many streams of the northeastern United States are during the greater part of the time, and under most conditions, an enormous asset to the region. At other times, and under some conditions, they are a very great liability. Both as an asset and a liability they are of extreme importance.

Because rates of run-off and stream flow are immensely increased by steep slopes protection of watersheds is particularly necessary in the more mountainous portions of the Northeast. The zone, shown in figure 3, where the forests are believed to exert a major influence on watersheds, is prevailingly mountainous, and includes most of the land previously described as very steep or steep. The forests here should be classified as protection forests. The area of moderate influence coincides roughly with the moderately steep and part of the gently rolling land, and that of slight influence with the remainder of the gently rolling and practically all of the flat land. There are local exceptions to these classifications, but only the coastal sands subject to wind erosion are large enough to map. The forest on the latter is today either in very bad shape or entirely lacking, but it or some other form of soil-binding vegetation is clearly needed. It should be noted that the relatively level watersheds from which many large municipalities in the region derive their domestic and industrial water have not been included in the area of major forest influence, although their inclusion might be justified by the critical importance of water in this zone of dense population. The low percentage of forest land, however, makes it difficult to justify such a classification in advance of evidence, drawn from local experimentation, on both the absolute influence and the relative influence of the forest as compared with very carefully managed agricultural crops.

Roughly, one third, or 14,000,000 acres, of the forest area of the region is included in each of the zones in which the forest is believed to exert a major, a moderate, and a slight influence on run-off and stream flow.

There is every reason to believe that whatever measures of protection and management promote other values of the northeastern forests will also increase their value as regulators of stream flow and preventives of erosion. They should be adopted forthwith. These measures, as described in other sections of this report, include (1) intensified fire protection wherever in the region recognized objectives of fire control have not yet been reached, (2) halting devastation of any land, public or private, and (3) improving watershed conditions by planting where necessary. Present knowledge leads to the belief that about a half million acres of major influence land in the northeastern drainages require planting for watershed purposes alone. If adequate fire protection and planting in certain localities—such as the anthracite coal region of Pennsylvania—involve expenditures so far beyond those which the private owner can afford to make that the public is forced to assume the greater part of the burden, outright public acquisition appears inescapable. Intensified fire protection and halting of devastation will go a long way toward protecting the existing forest cover against degeneration. The public need for water and for safety from floods and erosion suggests that some 7.8 millions acres should be publicly owned and managed. Approximately 900,000 acres of this total is abandoned farm land.

A third major need in the solution of the stream-flow and watershed problems of the region is research. There is need for exact experimental evidence on the relative water use of the different species of native vegetation under the climatic conditions peculiar to the region and under different geological conditions. Differences in interception of rainfall by the crowns, in rate of percolation and absorption through the leaf litter and in rate of snow melt beneath tree crowns, must be determined for various types and species. Control of drifting sands by vegetation should be studied. The effect upon run-off and stream flow of a mixed conifer and hardwood forest as compared with a pure forest of either conifers or hardwoods; the effect upon wind movement and evaporation of an all-aged forest as compared with an even-aged forest—these and similar problems arising out of intensive management may be solved only by experimentation. Research should be conducted first and on the most comprehensive scale in the zone of intensive use of water for domestic and industrial purposes.

SOUTH ATLANTIC DRAINAGES

The South Atlantic drainages, as the term is here used, include the Potomac River and all of the streams draining into the Atlantic Ocean southward from it, to but not including the Savannah River (fig. 4). Because of the difficulty of segregating for different portions of a

State many of the State-wide statistics later quoted, this report will make little or no reference to Maryland, and treats South Carolina as a unit.

CLIMATE AND PHYSIOGRAPHY

The region is one of abundant rainfall—40 to 50 inches annually at most points. A few valleys at the head of the Potomac River receive less than 35 inches of rainfall a year, and in South Carolina adjacent to the zone of highest precipitation in the eastern United States, the Blue Ridge receives an annual rainfall of 65 inches. Although there are no well-marked wet and dry seasons, rainfall is less equably distributed throughout the year than in the northeastern United

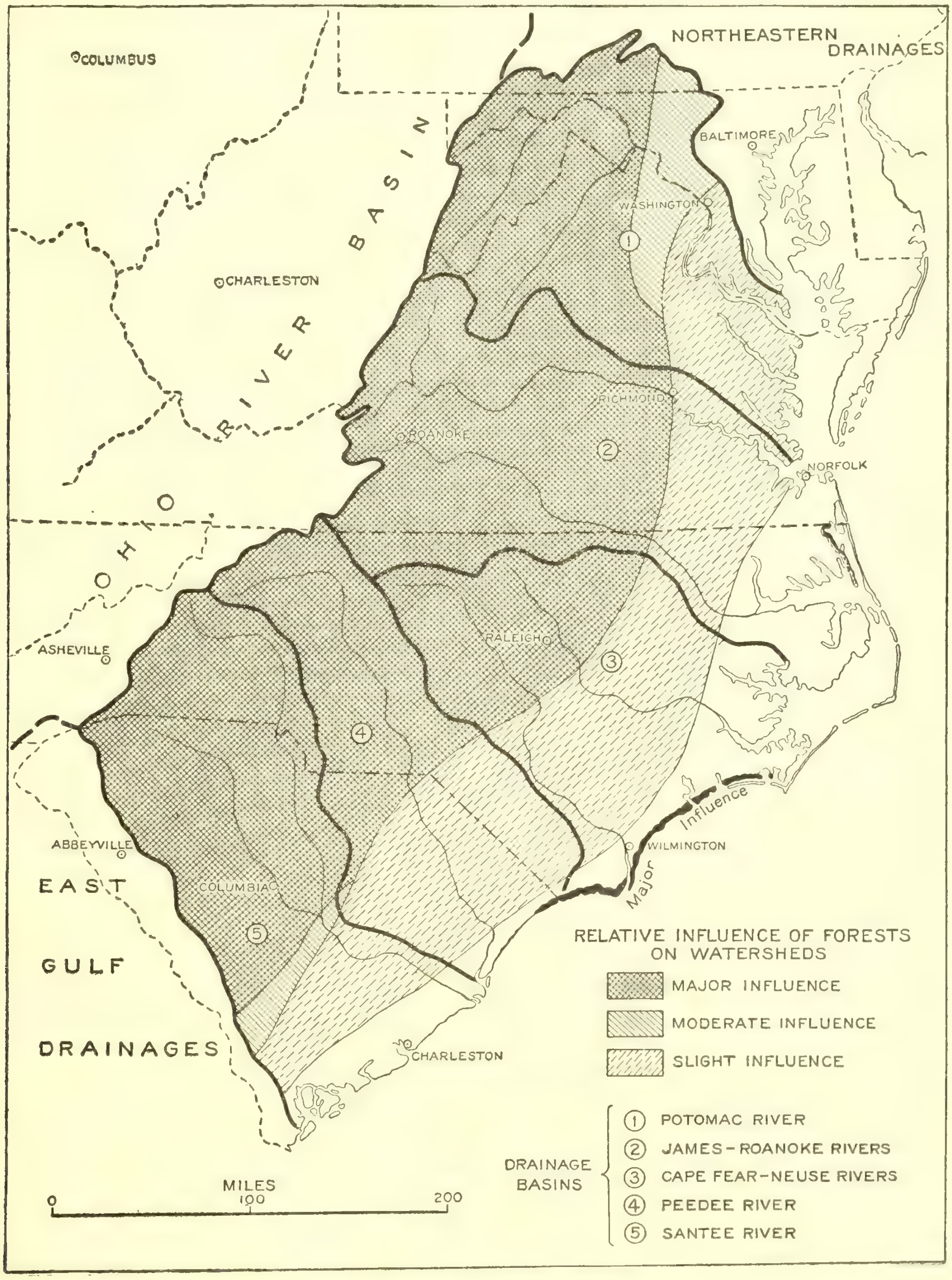
COLUMBUS
OHIO RIVER BASIN
CHARLESTON
NORTHEASTERN DRAINAGES
BALTIMORE
WASHINGTON
①
RICHMOND
ROANOKE
②
NORFOLK
ASHEVILLE
RALEIGH
③
④
Major Influence
WILMINGTON
ABBEVILLE
EAST GULF DRAINAGES
COLUMBIA
⑤
CHARLESTON
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
▨ MAJOR INFLUENCE
▨ MODERATE INFLUENCE
▨ SLIGHT INFLUENCE
DRAINAGE BASINS
① POTOMAC RIVER
② JAMES-ROANOKE RIVERS
③ CAPE FEAR-NEUSE RIVERS
④ PEEDEE RIVER
⑤ SANTEE RIVER
MILES
0
100
200

FIGURE 4.—South Atlantic drainages.

States. Midsummer precipitation, although high on the average, is irregular. At several places as much as 9 inches is recorded as having fallen in 24 hours, and at one point there is a record of 22 inches within 2 days.

Snowfall is generally unimportant, running from a yearly average of less than 5 inches along the seacoast of South Carolina to 30 or 40 inches on the upper Potomac watershed.

The region is divided into three distinct physiographic provinces: The coastal plain, the piedmont, and the Appalachian Mountains. The coastal plain rises from sea level to between 200 and 400 feet at the Fall Line, where it adjoins the piedmont. Considerably more than half of the coastal plain is flat, and below 100 feet in elevation, but with the rise in elevation westward the land becomes gently rolling, and breaks into rather sharp differences in elevation between the ridges and the stream bottoms. The piedmont plateau rises from the Fall Line to elevations of 600 to 1,500 feet; the general topography varies from gently rolling to somewhat broken.

From the western boundary of the piedmont plateau the mountain province rises, sometimes by as much as 2,000 feet in the space of 3 miles, to the summit of the Blue Ridge, which in the Carolinas is from 3,000 to over 4,000 feet above sea level. In the Virginias and Maryland the eastward flowing streams originate against ridges farther to the west, and flow in narrow gorges through the Blue Ridge which is here much lower in elevation than farther south.

The soils of the coastal plain are predominantly sandy, but there is considerable diversity as between the nearly pure sands of the Sand Hills, and the loams and even silt loams of other localities. The piedmont soils are predominantly deep clays, with some sandy loams, clay loams, and silts, which are particularly subject to erosion. The mountain soil types merge with those of the piedmont on the slopes of the Blue Ridge. Although on the whole remarkably deep for mountain soils, they are shallower, of lighter texture, and more stony than the piedmont soils. West of the Blue Ridge in Virginia many soils are derived from limestone and calcareous shales.

EROSION

Erosion, involving both deterioration of soil and the silting of reservoirs and navigable channels, is the overwhelmingly important watershed problem of the South Atlantic drainages, and one which has reached very serious proportions on the piedmont plateau and in adjacent portions of the other physiographic provinces.

The clays, clay loams, and silts which characterize the piedmont are subject to erosion wherever exposed by clearing or by lumbering and fire. They are particularly subject to erosion when loosened by plowing, and, as has already been stated, when robbed of organic material by long-continued cultivation or repeated forest fires. Silt lands erode even more readily than the compact clays. Surface run-off in time cuts tremendous winding gullies through such soils.

The piedmont soils probably erode more rapidly under even the most skilful cultivation than if the native vegetation had remained undisturbed. Unfortunately great areas of these soils have been handled with little skill. Thousands of fields in the piedmont have been plowed up and down hill instead of along the contours, or in terraces; cash crops—corn, cotton, and tobacco—have been grown under clean tillage; and the organic content of the soil has been steadily depleted. Tenancy has increased, in many counties up to 80 percent, and the irresponsible attitude of the typical tenant farmer has accentuated these tendencies. Whitney, in his "Soils of the United States", says of tenancy: "It is a general experience that soils deteriorate under tenant farmers, who have little interest in the welfare of the farm beyond the year of certain occupation and little capital and insufficient stock to work with."

Fairfield County, in the Santee River drainage of South Carolina, is an example of the erosion situation in the piedmont. The soil survey of this county in 1912 showed that 90,000 acres of land, largely cultivated at one time, had been permanently ruined by erosion. The whole area has been dissected by gullies, and bedrock is exposed in thousands of places. The State Forester estimates that in each of the adjoining counties from 10,000 to 30,000 acres have been similarly injured. W. W. Ashe computed in 1908 that an average of more than 850 pounds of soil per acre were yearly washed from the watershed of the Yadkin River above Salisbury, N.C. Of this more than125 pounds was humus, chiefly from farming soils, and the balance mineral soil.

Erosion from cleared lands, continues at least for a period, when the lands pass out of agricultural use. If the abandonment is permanent, they become potential forest land, and their erosion is the forester's problem. In the past two decades there has been a general decline in rural population and an increase in land abandonment.

Opinions differ as to how rapidly abandoned farm lands in the piedmont will revert to forest or other volunteer cover, and thereby be preserved against further serious erosion. The county demonstration agent of Fairfield County, S.C., believes that 75 percent of the gullied land in this county will restock naturally within 3 to 5 years. On the other hand, the extension forester of North Carolina, who estimates that for his State as a whole there are approximately 2 million acres of idle and submarginal cleared lands which should be returned to forest, believes that only 50 percent of this will restock naturally within 10 years. The other 50 percent, he asserts, will require definite planting, and 25 percent, or 500,000 acres, will require some mechanical assistance such as soil saving and brush dams, plowing in of gullies, etc.

Unquestionably such differences of opinion arise out of variations in the condition throughout the very large territory involved. The light-seeded loblolly and shortleaf pines characteristic of the region are difficult to keep out of cleared land adjacent to mature stands, but a few scattered trees along fence rows across large cleared areas cannot be counted upon to seed the land promptly and effectively after abandonment for cultivation.

Poorly farmed land and abandoned farm land are the chief sufferers from erosion on the piedmont plateau. A third class of land which is subject to some degree of erosion is heavily cut and repeatedly burned forest. Abused forest land is important because even on the piedmont a considerable percentage of the land is in woods; only two counties out of all those in the region have less than 20 percent of their area in forest and only 24 show less than 40 percent of forest cover. Leaf litter from several years' fall accumulates on forested ground. A single fire may remove this entire protective mantle. Heavy cutting of the forest prevents its prompt replacement. Because hardwood leaf litter blows from place to place, and may thereby be absent from considerable areas, any cutting in mixed stands of pine and hardwoods that reduces the proportion of pine encourages erosion.

In the mountain province, in spite of heavy and often concentrated precipitation and abuse of the forest by fire and cutting, the streams from forested watersheds run extraordinarily clear. However, the soils of the mountain area are easily eroded when exposed. Land clearing for agricultural purposes, although of minor importance as far as area is concerned, is a major factor in erosion. Indeed, so rapidly does erosion take place that many fields are eroded and abandoned before the girdled trees have fallen. Geologists, foresters, and agriculturists alike agree in ascribing most of the erosion in the mountains to land clearing and to agriculture on steep slopes.

Investigations by the Geological Survey [32] in the southern Applachian region have shown that erosion takes place almost universally on cleared slopes. Glenn estimates that slopes in excess of 15 percent should not be cleared although as he points out, some slopes of 10 percent erode faster than those of 30 percent. What the safe gradient should be in any case depends upon the erosive characteristics of the soil. The soil of some fields is so impoverished by erosion that vegetation is unable to obtain a foothold and gullies continue to erode actively long after the abandonment has taken place. In places, the deeper gullies even eat back into the forest before the erosion is finally checked.

Measurements were made by the Appalachian Forest Experiment Station of the dry weight of suspended matter found in streams of western North Carolina following heavy rains in August, 1928. These showed that as the percentage of cultivated area in the drainage increased, a progressive increase occurred in the amount of silt carried by the stream. This ranged from 4,370 parts per million on a watershed from 85 to 90 percent in cultivation to 11 parts on a watershed where only 5 or 10 percent of the area was cleared. The material obtained from the agricultural watersheds was fine sand, clay, and silt; from the forested watersheds, mostly organic matter.

Grazing, although not important as a whole, is locally a cause of serious erosion. Too intensive grazing use and pasturage of steep slopes have been responsible for deep gullying. On some of the "balds," cattle trails have resulted in erosion which, spreading rapidly in the shallow soil, has exposed large areas of rock.

Timber cutting is often of little consequence as a source of erosion because new growth returns to the land quickly. Cutting, however, is often followed by slash fires which result in understocked stands and in these, erosion often continues for many years. In many cases, the dragging of logs down mountain slopes starts small gullies, but these are usually soon healed over.

Erosion is not a great problem in most parts of the coastal plain. Large areas near the coast are so close to tide level that exceptionally heavy precipitation, or overflow from the streams, remain on the surface of the ground for considerable periods before finally draining away. At higher elevations percolation of rainfall into the sandier soils is very rapid. It is only where a loamy condition is approached that there is appreciable sheet erosion even from cultivated soils.

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[32] Glenn, L. C. Denudation and Erosion in the Southern Appalachian Region. U.S.Geol.Sur.Prof. Paper 72. 1911.

The relation of forest cover to erosion and other watershed and stream flow problems in the South Atlantic drainages is diagramatically shown in figure 4. In the mountains steep slopes and relatively heavy rainfall combine to make a permanent vegetative cover necessary if erosion is to be minimized. Forests still cover a high percentage of the mountains, and clearly exert a major influence on erosion. A considerably smaller proportion of land remains forested on the piedmont, in the mountain valleys of Virginia, and on the coastal plain adjoining the piedmont, where topography is only moderately broken and slopes are relatively short. In spite of this fact the absolute area of forest is so large, and erosion of the cleared land is so general, that here also the forest is considered to exert a major influence. The forests of the mountains, the piedmont plateau, and a strip of the coastal plain bordering the plateau may properly be classified as protection forest. In the greater part of the coastal plain, however, low relief would render serious erosion unlikely even in the absence of forests.

Wind erosion is common along the seacoast, where sand dunes occur. The drifting sand is held in place in some localities by a cover of pine and brush species, but elsewhere marches upon roads and other improvements, and in some places fills dredged channels. Fixation of drifting sand is a problem of some importance at points along several hundred miles of coast in Virginia and the Carolinas.

WATER POWER

Water power is an extremely important and valuable natural resource in the South Atlantic drainages. According to the United States Geological Survey, North Carolina ranked third among all States in the Union in 1929 in generation of power from streams, and South Carolina ranked sixth.

Water storage on a large scale is highly desirable in producing power in this region, because of the extreme fluctuations in stream flow. The maximum flow of the major streams is here from 150 to 400 times the minimum flow; this contrasts with a ratio of 100 to 1 in the case of the Kennebec River in Maine. In order to maintain a steady flow for the generation of water power, artificial reservoirs have been created. The reservoir at Dreher Shoals, on the Saluda River in South Carolina, has a storage capacity of 524 billion gallons, which is said to be the largest capacity of any reservoir constructed for power, flood control, or water supply in the United States.

Control of silting is a grave problem in the management of storage reservoirs throughout the region. The Whitney Dam, above Badin, N.C., on the Yadkin River, was a 38-foot dam constructed in 1910. In 15 years silt filled the reservoir within a few feet of the top of the dam. Another example of a reservoir completely filled with silt from erosion is the Parr Shoals Reservoir in Saluda County, S.C.

NAVIGATION

Maintenance of navigable channels in streams and harbors, in the face of continuous deposition of enormous quantities of solid matter—the product of erosion, is the third major stream-flow problem of the region. According to the Chief of Engineers of the United States Army, about 7,860,000 short tons of freight were carried on the 14 principal rivers of the South Atlantic drainages in 1928.

The 1932 report of the Chief of Engineers shows that enormous sums have been spent by the War Department during the past 50 years in the improvement, chiefly by dredging, of these navigable waterways and harbors. Existing improvement projects have cost about $33,000,000 in that period.

The total sum spent by the United States in the improvement and maintenance of channels in South Atlantic streams, since the founding of the Republic, would come to a much larger sum.

FLOODS

As might be expected in a region where differences of 30 to 60 feet in the height of large streams may occur within a few months, floods are sometimes very destructive. They are generally the result of a succession of rains, rather than of a single very heavy storm. The Santee River drainage basin, a high proportion of which has been cleared, appears to suffer particularly heavy losses, although records are fragmentary. Near Spartanburg, a flood in June 1903 took over 50 lives, swept away 14 cotton mills, and caused a total property damage of over $3,500,000. Unofficial figures, furnished by the State forester from Weather Bureau sources, indicate that between 1913 and 1922 South Carolina suffered losses of $19,337,000—practically $2,000,000 a year. Among recent floods in the region as a whole those of 1928 and 1929 were the most severe, causing damages in the three States of over $9,000,000. Virginia has suffered much less than the Carolinas from high water.

Glenn has indicated the great change which has taken place in the behavior of the South Atlantic streams. In addition to increased silting, this change has included greater irregularity of flow, and more frequent and higher flood stages. He states that this change is "reasonably believed to be due to the denudation of steep mountain slopes and their consequent erosion." Most of the change in the behavior of the streams he places at about the period of 1885 to 1890 when there was a rather general revival of industrial activity after the slow recuperation from the Civil War depression.

URBAN WATER SUPPLIES

A considerable number of municipalities in the region derive their water supply from surface streams. Among these are Richmond, Va.; Raleigh and Charlotte, N.C.; and Spartanburg and Columbia, S.C. Storage is necessary, and here also control of silting presents a problem. For example, the municipal reservoir built by Raleigh in 1914 has been reduced more than one third in capacity by silt from the cleared land which makes up a portion of its watershed. A reservoir built in 1923, the watershed of which is wooded, has been silted very slightly.

PERCENTAGE FORESTED

About two thirds of the total acreage of the region is in forest cover—probably a higher percentage than in the earlier period when land clearing was at its height. The forest is remarkably evenly distributed. The proportion varies from 50 to 75 percent as between the larger drainages. A considerably higher percentage of the mountain and the coastal plain provinces is forested than of the piedmont province, but, as already stated, only 24 counties in the region show less than 40 percent forest cover, and only 2 less than 20 percent.

ORIGINAL AND PRESENT CHARACTER OF FOREST AS INFLUENCING EROSION AND STREAM FLOW

Comparatively little of the virgin timber of the region now remains. A large area has been cleared for agriculture. Some of it went back to forest during the Civil War, and some has again been cleared. On the piedmont farm woods are typically interspersed with agricultural land. But on the poorer sandy lands and alluvial bottom lands of the coastal plain, and in the rougher portions of the mountains there are extensive and continuous forests.

In the mountains, about 70 percent of the area is in forest. This is largely a mixture of oaks, hickories, tulip poplar, ash, maple, beech, basswood, chestnut, and a large number of other species. Repeated culling of the better quality woods has converted much of the original high-grade forest into an inferior one. Fire has resulted in further depletion of the culled stands, until now the forest in many places is for the present almost worthless commercially. The most obvious effect of fires on watershed protective values is the destruction of leaf litter. Litter under a good forest cover in the mountains accumulates to a depth of several inches; its dry weight, in one study made by the Appalachian Forest Experiment Station, was found to be as much as 13,000 pounds an acre. Other studies by the station show that it may absorb up to four and one half times its own weight of moisture. This retention of water by litter may itself be important in lessening run-off from heavy storms, but its effect has been shown by experiments in this region and elsewhere to be completely overshadowed in value by the favorable effect of litter upon absorption of water into the soil below. When litter is destroyed, as by fire, the soil soon becomes less porous, and less able to store large quantities of water. Fire protection in the mountain region is variable. In some places, as on the national forests, fire losses have been kept to a reasonably satisfactory figure. State and county effort has developed well in part of the region. Private efforts at protection of the forest against fire are sporadic.

The forests of the piedmont are characteristically a mixture of hardwoods and pines. Pure hardwood stands are common, as are pure stands of shortleaf and Virginia pines at the north, and of shortleaf and loblolly at the south. In places a mixed hardwood forest is found. The farm woodlands, being isolated, have suffered less from fires than have the large continuous areas of forest land in the mountains, and the cutting methods applied to them have probably been less destructive than those employed elsewhere. Grazing, which is permitted in many farm woodlands, is a severe handicap to young growth.

On the coastal plain, from Virginia south, the original upland forest was dominated by longleaf pine, although on the more compact clays and silts loblolly pine, and in South Carolina slash pine took its place.

Hardwoods, such as oaks and gums, formed an important part of the forest. Along the rivers and in the coastal swamps a mixed forest occurred, but cypress and southern white cedar were also of great importance. The forests of the coastal plain have been cut very heavily. Longleaf pine has been practically exterminated from Virginia, and in North Carolina it has been very largely replaced by loblolly pine. Fires have been particularly frequent and widespread in the coastal plain, and would have devastated wide areas had not the indigenous species of pine, particularly longleaf, been relatively resistant. In Virginia and the Carolinas as a whole an average of 366,000 acres of land under protection burned yearly between 1926 and 1930. Of the millions of acres not protected in the region, it was estimated that in 1931 about one quarter burned over. Statistics for the coastal plain separately are lacking, but it is probable that the bulk of the fires occurred in this physiographic province.

By far the greater area of forest lands in the South Atlantic drainages are in private ownership, and the present impoverished condition of the watershed cover is a reflection of private land management. Some national forest lands purchased in the mountain area are in decided contrast to the private lands because in the past 20 years they have received incomparably better fire protection, the cutting has been done in such way as to encourage regrowth, and the badly eroded agricultural lands have largely reforested. Although a full cover has not yet developed in the short time these lands have been administered, watershed conditions have steadily improved. Private lands, however, still evidence the lack of adequate protection and management. Conditions on State and other local public lands, with some notable exceptions, resemble more those on the privately owned land than they do those on the national forests.

CONCLUSIONS

That a permanent vegetative cover on a watershed is a powerful preventive of erosion is clearly shown in the South Atlantic drainages by the relative clarity, even in flood, of streams flowing from land in forest or permanent sod, as compared with the turbidity and heavy silt load characteristic of streams flowing from cultivated land. Although there has not been enough experimentation in this region to furnish conclusive evidence that forests exert other favorable influences on streamflow, research elsewhere in the United States, even though with other forest types, climates, and soils, tends to the belief that they do. The magnitude and gravity of the erosion and streamflow problems of the South Atlantic drainages certainly warrant the following conclusions: (1) That where forests already exist in the region they should be protected against fires, destructive lumbering, and other treatment likely to impair their favorable influence on erosion and streamflow, and (2) that where erosion of land now cleared has forced, or is forcing, its abandonment for agriculture, its prompt reforestation and administration as a permanent protection forest are necessary.

First-class fire protection is justified from every point of view—either that of reaping a full crop of wood under a climate favorable to rapid growth, or of realizing the full indirect benefits of a forest cover. A very small percentage of the region is now receiving first class fire protection. After 18 years' effort Virginia does not even attempt to protect more than 63 percent of her forest area, and after 18 years North Carolina does not attempt to protect more than 39 percent. In South Carolina only the barest start has yet been made toward fire protection. Even within the protected areas the percentage of burn in 1931 ranged from 1.4 in Virginia to 7.7 in South Carolina. The standards set up in the section "Protection Against Fire" should by all means be put into effect in the region, through the combined efforts of the public and the landowners.

Such simple restrictions upon cutting and grazing as are necessary to prevent devastation of forest land (see the section "How to Stop Forest Devastation"), and control of epidemic insects and diseases, are obligations of ownership, and may be expected to contribute to the beneficial influence of the South Atlantic forests on erosion and streamflow.

Restrictions are also necessary upon clearing of steep slopes because such clearing is a very fruitful source of erosion and heavy surface run-off.

Again, as in the Northeast, there is a very great need for substantial research into the relationship of forests and waters, including water use by different species of trees and other natural vegetation; interception of rainfall by crowns; capacity of leaf litter to absorb and to filter precipitation; nature and condition of the organic layers of the soil in relation to percolation and run-off; effect upon wind movement and evaporation of pure versus mixed forest, and of even-aged versus all-aged stands; and control of drifting sands by tree growth.

The most critical watershed and streamflow problem of the South Atlantic drainages, however, is not that of land now in forest, but of cleared land which has been abandoned for agricultural use, or which, under present methods of farm management, is certain to erode until so abandoned. The Bureau of Agricultural Economics estimates the present area of abandoned farm land available for forestry in Virginia and the Carolinas at slightly more than 5 million acres. Although no direct evidence is available on the point, it is probable that approximately two thirds of this area, or roughly 3.3 million acres, is eroding seriously. In so far as improved farm management can save eroding lands still in agricultural use from further deterioration, and can point the way to their continued use at a profit, the erosion problem is not one for the forester. But if abandonment of agricultural land continues here at the rate predicted by the Bureau for the nation as a whole, by 1950 over 2½ million acres—probably half of it eroded—will be added to the present abandoned acreage, and reforestation will be the only alternative to completely ignoring the erosion menace.

Prompt reforestation of these abandoned farm lands is necessary to meet the menace. If the estimate of the local foresters that a large part of eroded farm land will reforest naturally within 10 years of abandonment are applied to the region, planting will have to be done on about 2 million acres. It also seems probable that of this huge area of abandoned farm lands, about 1 million acres will require preliminary treatment, such as plowing in of gullies and building dams. It is very difficult to see how the landowner can be persuaded to undertake such work on any adequate scale. It is entirely out of the question to interest a tenant in it.

Public acquisition and management of 3.3 million acres of abandoned lands or of such submarginal farm lands clearly headed for abandonment, none of which will reforest naturally within a decade, appears to be the only prompt and effective solution of the erosion problem on much of the piedmont plateau, in adjacent portions of the coastal plain, and in the mountains. Wherever the areas to be acquired are scattered, or difficult to administer because of small size, local handling—preferably by counties—is naturally suggested. But it is very doubtful whether counties that have suffered a continuous shrinkage in their area of improved farm land, and even the States themselves that have not yet financed State-wide fire protection, can handle a purchase, planting, and engineering investment covering hundreds of thousands of acres. Even if tax-title were obtainable, there would still remain the planting and other items, and subsequent annual costs of protection and administration. Heavy Federal participation seems inevitable. It is certainly logical for the Federal Government, which has spent $33,000,000 on dredging and other maintenance of navigable streams within the States comprising the South Atlantic drainages, to spend a few million dollars additional to safeguard its investment.

Similarly, the large area of mismanaged and inadequately protected forest land in the mountains and in the piedmont should also be in the hands of the public. Administration of a type similar to that given the national forests would meet the watershed situation and restore the streams to their pristine condition. All of the forest area of major influence, some 15½ million acres, should be in public ownership. Whether these lands, like the abandoned agricultural lands, should become national forest, or county and State forest through some form of Federal cooperation, is a detail to be worked out when all the facts have been more carefully ascertained than at present.

EAST GULF DRAINAGES

The East Gulf drainages as here discussed include those portions of the Southern States drained by the rivers from the Savannah to the Mississippi. As shown in the accompanying map, figure 5, there are seven of these rivers. The map shows the areas on which according to our present knowledge a forest cover exerts or should exert a favorable influence upon stream flow and erosion, and in a general way indicates the relative degree of this influence. The forest areas of the drainages are classified according to watershed protective influence as follows:

	Acres
Major influence	18, 709, 000
Moderate influence	4, 335, 000
Slight influence	50, 269, 000

The southern portion of Florida, which is not shown on the map, and the portion of south Georgia that drains into the Okefenokee Swamp present no watershed protection problem. They are very flat and very near tidewater level. Much of the excess water from torrential rains collects in swamps and runs off slowly. The soils are mostly absorptive sands, and comparatively little erosion takes place on the cultivated lands.

In Florida the more inland dunes, as on the Chocatawhatchee and Ocala National Forests, have become stabilized under a forest or brush cover. Some of the coastal dunes are in motion because of distrubance to the cover or of the inability of vegetation to become established. Occasionally dune movement threatens roads or other improvements, but for the most part, the moving dunes do little damage.

FACTORS IN STREAM FLOW AND EROSION

PRECIPITATION

The East Gulf States receive about 55 inches of rainfall annually. Rains occur throughout the year. Heavy torrential rains are common close to the Gulf and also, to a lesser degree, in the interior.

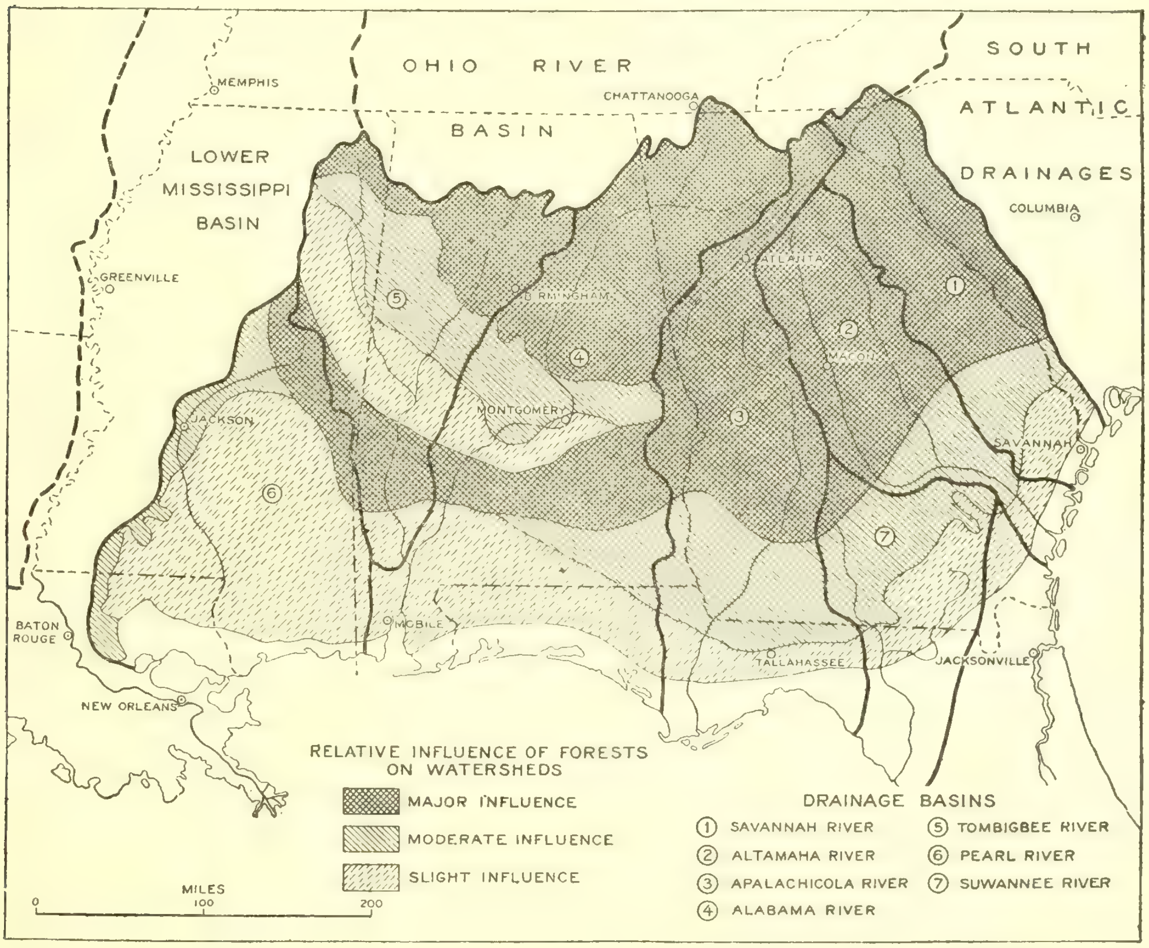
OHIO RIVER BASIN
SOUTH ATLANTIC DRAINAGES
LOWER MISSISSIPPI BASIN
MEMPHIS
CHATTANOOGA
COLUMBIA
ATLANTA
BIRMINGHAM
MACON
MONTGOMERY
JACKSON
SAVANNAH
GREENVILLE
BATON ROUGE
MOBILE
TALLAHASSEE
JACKSONVILLE
NEW ORLEANS
①
②
③
④
⑤
⑥
⑦
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
DRAINAGE BASINS
① SAVANNAH RIVER
② ALTAMAHA RIVER
③ APALACHICOLA RIVER
④ ALABAMA RIVER
⑤ TOMBIGBEE RIVER
⑥ PEARL RIVER
⑦ SUWANNEE RIVER
MILES
0
100
200

FIGURE 5.—East Gulf drainages.

Weather Bureau precipitation records for the Alabama River drainage show a wide variation in the quantity of rainfall that occurs in individual storms. In one instance in the basin of the Coosa River, a major tributary in central Alabama, the rainfall ranged from 8 to 20 inches.

Rainfall exceeding 2 inches in 24 hours is not uncommon; indeed, summer rains of more than 5 inches in a 12-hour period have been recorded. Storms of such intensity, particularly if the soil happens to contain much moisture at the time, result in major floods and widespread erosion. Some storms cover a relatively narrow belt, others are widespread. Some storms, principally in the fall, originate as tropical hurricanes. Most of the rains causing severe floods come in the winter or spring.

TOPOGRAPHY

The East Gulf area may be divided into three physiographic provinces; the coastal plain, the piedmont, and the Appalachian highlands. The Coastal Plain rises from sea level to between 200 and 400 feet, where it adjoins the piedmont. Much of the Coastal Plain area is flat and less than 100 feet in elevation. Inland the elevation increases more rapidly, the land becomes more rolling, and occasionally sharp differences in elevation occur. The piedmont rises to elevations of 600 to 1,200 feet, the topography varying from rolling to broken. Most of the hills are broad and of such even slope that agriculture early claimed a large part of the hill land. The Appalachian highlands rise to a maximum elevation of about 4,000 feet in northern Georgia, at the southern end of the Appalachian Mountains. Rough topography is characteristic of much of the highland area.

It is largely because of steep slopes and rapid run-off from bared soils that a very large part of the highland forest is classed as having a major influence on watershed conditions. It is largely because of poor drainage due to insufficiency of relief that the Coastal Plain forest is classed as having little influence upon watershed conditions.

SOILS

In the Coastal Plain, absorptive sands are the predominate soil type. These are comparatively shallow on some areas where hardpan has developed. On the upper Coastal Plain the sandy soils give way to highly erosible loams.

The piedmont soils are predominantly deep clays, which erode rapidly when exposed. Cultivation greatly hastens erosion. Although the piedmont subsoils unlike most others, can be cultivated if fertilized, yet here as elsewhere the subsoils are much inferior to surface soils in both absorptive and water-holding capacity. Consequently, exposure of subsoils over large areas increases floods and renders stabilization of streamflow difficult. It is largely because of their easily eroded soils that the forests of the piedmont are classed as having a major influence.

The soils of the highlands are inclined to be stony. Some are clay soils derived from limestone and shales, others are loam. Save for occasional pockets of deep loam and for rare areas unburned by recurrent fires, the highland soils are much shallower and poorer than those of the piedmont. For this reason they do not absorb and hold as much water as the piedmont soils. The fact that they are shallow makes it all the more necessary to maintain the cover upon them intact.

FOREST CONDITIONS

In the highland section, hardwoods predominate. At less pronounced elevations pines, particularly shortleaf, occur with the hardwoods. This mixed forest has been repeatedly culled of its best timber. In places it has been severely cut and repeatedly burned, with the result that it has been converted into a more or less open and scrubby woodland. On approximately 20 percent of the forest land in the highlands the forest stands have been either destroyed or badly culled and burned. Much of this land is pastured, and this form of use intensifies the deterioration of the remaining forest.

Many slopes in the highlands have been cleared and put into crops. Observations indicate that on slopes steeper than about 15 percent agricultural use leads to gullying so severe that the land is quickly abandoned.

Privately-owned forest lands in the highland section burn frequently. Hardwood sprouts and other vegetation come in on some areas denuded by fire, but because of fire many cut-over lands have failed to restock quickly and are without adequate litter and humus. On public forest areas such as the Cherokee and Alabama National Forests, litter and humus have developed under fire protection. These national forests were established at the headwaters of the Apalachicola and Black Warrior Rivers because of the influence of the areas on stream flow and erosion. That this influence is decidedly beneficial is shown by the fact that the streams from the national-forest areas, formerly muddy, now usually run clear.

In the Piedmont and Coastal Plain sections, where pines predominate, fires are much more common. In the piedmont section, where much of the forest area is on farms, pasturing and fires go together.

Most of the upland pine forest is second growth. In logging pine stands it is customary to cut fairly clean, but usually a sufficient seed supply has been available to insure reforestation if fires are not too destructive. This is evidenced by the fact that although severe cutting and repeated burning have occurred extensively on the pine lands, only about 5 percent of these lands have been devastated. Fires kill small loblolly seedlings; shortleaf has the faculty of sprouting after being burned. Both pines are resistant to light ground fire after they have reached a diameter of a few inches.

Longleaf is the predominating tree of the Coastal Plain forest. Usually, before the mature pine forest is cut all trees large enough to support a turpentine face are worked for naval stores. Frequent fires before the naval stores operation and annual fires during it destory much advance growth. In logging, the trees large enough for the saw are cut first, then the larger trees that have survived the subsequent fires are taken for poles and piling. In some localities, logging followed by fire leaves the land completely devastated. On some areas, conversion from forest to grassland has taken place within a very few years. Only the remarkable persistence of longleaf seedlings in the face of repeated fire and the ability of the saplings to survive defoliation prevent this species from being almost wholly destroyed. As it is, something like 10 percent of the longleaf area has been devastated. If given a chance, however, the longleaf with the help of other species such as slash and loblolly reclaims some of the denuded areas. Clear cutting is less usual with second-growth stands, but they are heavily worked for turpentine and are subjected to frequent fires.

In the more moist parts of the lower Coastal Plain slash pine occurs with the longleaf. Practically all this is second growth. The slash pine is much more susceptible to fires in early youth than the longleaf, and escapes only because of its ability to grow in moist locations. During drouth, fires in these locations play havoc with the pine stands.

Cutting in the southern forests need not be destructive. In some places greater care in logging may be required than in others; on the whole, it should not be difficult to utilize both the timber and the forage and yet maintain satisfactory watershed conditions. Control of fire, often set purposely, is far more necessary than any great change in cutting methods. Adoption by landowners of the standards set up in the section of this report entitled "Protection Against Fire" would satisfactorily meet watershed protection needs on private forest lands.

In Georgia, Florida, Alabama, and Mississippi, good fire-control organizations have been developed in some localities but only 20 percent of the forest area is protected. Until better fire control can be provided or until local woods-burning practices change, it will be impossible to get adequate protection. In 1929 and 1930 about 29 million acres, or 40 percent, of the total forest area not now protected (about 71 million acres) burned over each year. Where fires annually cover large areas of forest land, not even a scanty litter cover can develop.

Probably the largest fire-control effort of a single landholder is that of the Great Southern Lumber Co., in southeastern Louisiana. This company has succeeded in protecting its lands from fire largely because it has bought many of the small intermingled holdings and put considerable forest acreage under a tight fence. The latter has not only interfered with trespass and eliminated grazing fires but also excluded the hogs which destroy young longleaf seedlings.

Cattle grazing on forest areas is widespread, especially in the pine regions, but probably does little if any damage to the watersheds. Only locally, and usually only on farms, does overgrazing of consequence occur.

Forest conditions such as those described do not tend to regulate stream flow or to prevent erosion. The open forest does not develop a full litter cover even if unburned, and grass often occupies the space between the trees. As indicated in the introduction to this section, grassland has a higher surface run-off rate than forest. Thus a reduction in the density of the forest tends to increase flood heights.

How far a change from good forest cover to scrub or sprout forest cover affects surface run-off and erosion in this region is unknown. Data taken by the Southern Forest Experiment Station in the silt loam uplands of northern Mississippi show that a scrub forest helps to retard surface run-off in times of heavy rain. A dense scrub or sprout forest can probably prevent erosion, but all too often the sprout stand to which cutting and fire convert a high forest is an understocked stand. Such a forest certainly burns more frequently than the forest it succeeds.

STREAM FLOW

The streams coming from the Blue Ridge highlands have a greater annual run-off than any other streams of the East Gulf drainages, the discharge being approximately equivalent to 30 inches of precipitation over their watersheds. Those from the piedmont and the coastal plain have a run-off equivalent to a precipitation of 20 to 25 inches. Fluctuation in flow is much less for the highland streams than for those of the piedmont and coastal plain; their ratio of minimum to maximum flow is about 1 to 100, whereas the Tallapoosa, for example, fluctuates from 65 to 102,000 second-feet, a minimum to maximum ratio of 1 to 1,569. The Army Engineers report that "in common with all rivers rising in the Appalachian Mountains, the (Apalachicola River) system exhibits a wide periodic fluctuation in volume of flow.

During dry periods the flow at the headwaters is well sustained through ground storage. The effect of low water is severely felt in that portion of the drainage area lying in the piedmont upland and the upper portions of the coastal plain." This undoubtedly is a reflection of forest conditions, since the forest occupies perhaps 60 percent of the total area in the highland section as contrasted with about 30 percent in the piedmont. It is more than coincidence that most of the power development is in the section where the largest area of forest is located.

At one time all the major East Gulf drainage streams were much used for navigation. Prior to the time of the railroads the head of navigation for the Apalachicola River was Columbus, Ga., 276 miles upstream. The upper stretches of the Apalachicola are no longer navigable except for the very lightest craft. On the Chattahoochee considerable sums have been spent by the Army Engineers in recent years to maintain an open channel of 4 feet. The report of the Inland Waterways Commission (1908) says of the Pearl: "This river has completely changed its character in the past 50 years; from a slow, clear stream it has become a swift, muddy one and from a good channel with a depth of 5 or 6 feet, it is now shallow and much obstructed by logs and drifts." In the Pearl River the available low draft for the lower 104 miles has decreased since 1875 to 2 feet, and in consequence all navigation-maintenance work by the Federal Government has been dropped. This change, which is common to all the East Gulf streams, reflects to a considerable degree the decrease in forest area and the degradation of the forest itself. It also reflects the decreased absorptive capacity of the soil brought about by agriculture and erosion.

Floods are not uncommon in this region. For their size they cause surprisingly slight property damage, largely because property values in the flooded areas are low and because the region is without a large urban population. Flood stages have been reached on the Chattahoochee River in 16 instances since 1900, and on the Tombigbee in 98 instances since 1903. On the average these high-water stages have lasted about 10 days each, but the most disastrous flood, in 1916, lasted 66 days. Nearly $100,000 was spent in aiding the victims of this flood. The average crop losses due to floods in the lowlands have been estimated at $3 per acre per year.

The floods of March 1929 caused damage estimated by the Weather Bureau to exceed $5,000,000 in the Choctawhatchee Basin, $1,000,000 in the Apalachicola, and $1,700,000 in the Alabama, in addition to heavy losses in other river basins. Cities such as Jackson, Miss., West Point, Ga., and Montgomery, Ala., have experienced serious inconvenience if not distress because high water entered the city water supplies, interfered with power and light service, or disrupted transportation systems.

EROSION

Under the agricultural practices in effect in the piedmont and upper coastal plain, the top soil has been sluiced from thousands of acres of farm lands. As a result, a large area has lost its productivity. Some lands have been so gullied as to become worthless for agriculture. As in the South Atlantic drainages, a very large part of the agricultural land is being cultivated under a tenant system. In general this system is characterized by indifference on the part of both the owner and the tenant toward the condition of the land. Census data show that in some counties negro tenants, many of them illiterate, are farming more than 80 percent of the crop lands.

According to H. H. Bennett, of the Bureau of Chemistry and Soils, much of the sloping land in the piedmont region on which pure stands of second-growth pine are growing is abandoned agricultural land from which the original soil was completely washed away. Mr. Bennett reports that in Spartanburg County, S. C., examination of the soil profile in remnants of the virgin forest of mixed hardwoods and pine showed the original soil to have consisted of about 4 to 8 inches of brownish or yellowish mellow sandy loam and loam. This top layer is gone or largely gone from 297,000 acres.

The loss of productivity on the eroded agricultural lands is reflected by census data. These show some 6½ million acres of farm land in the East Gulf drainages to have been abandoned in the past 20 years. Census data for Georgia show that the area of cultivated lands has decreased by 70 percent in Muscogee County, by 65 percent in Chattahoochee County, and by 51 percent in Hancock and Lincoln Counties. A reduction of almost 40 percent is shown for Coosa and Tallapoosa Counties, Ala., and similar reductions for counties in Mississippi. On many of the abandoned lands erosion is continuing.

In the report on a soil survey of Muscogee County, Ga., made in 1922 by the Federal Bureau of Soils in cooperation with the Georgia State College of Agriculture, it is stated that:

> Most of this soil type (Norfolk sand) was formerly cleared and farmed for a time because of its easy cultivation, but yields were small and erosion was so excessive that much of it was abandoned and allowed to grow up in pine and oaks. * * *. (The Norfolk sandy loam is) one of the most intensively farmed soils in the county * * *. The steeper eroded portions are allowed to remain in brush and pine.
>
> The construction of terraces on the slopes (Cecil soils) for the prevention of erosion and washing is now customary, and if this policy had been adopted when the land was first cleared many of the gullied fields that have since been turned out and allowed to grow up in pine and brush could be in use today * * *. Great care must be taken to prevent gullies from starting (in the Greenville clay loam), for they quickly destroy valuable fields if allowed to go unchecked. * * *. A large part of it (the Susquehanna clay) was originally cleared and considered excellent cotton soil, but erosion quickly made it of little value and it was abandoned. Most of it at present supports a growth of scrub oak and short-leaf pine.

The report on the soil survey of Stewart County, in western Georgia, made in 1903, states:

> A lower belt of broken country has been formed by the originally smooth upland being dissected by stream erosion. This belt is characterized by deep gullies, steep hills, and ridges with undulating crests. Some of the deeper gullies, locally called "caves", vary in width from a few feet to one fourth mile, and in depth from 50 feet to 100 feet or more. Their sides are precipitous or perpendicular. The roughest topography in this belt is south of Providence Church, where the surface is very broken, being probably the roughest section in the southern part of the State. In this section there is scarcely an area of land suitable for agriculture the size of an ordinary garden. Steep ridges rise to an elevation of 200 feet or more above the deeper stream bottoms. The country is so rough and broken as to lead some of the inhabitants of the county erroneously to believe that the hills are a southern extension of the Appalachian Mountains.
>
> The majority of the settlers occupied the clay hills, the level section of the county being avoided until a later day because of a belief that the land was of poor quality. Subsequently, the hill country became so badly gullied by erosion that this region was almost entirely abandoned. Many substantial buildings in

> the vicinity of Louvale, Union, and Providence, abandoned many years ago, remain as an evidence of the early settlements. * * *. There is little possibility of this gullied land being restored to a condition favorable to cultivation. * * *. Except where some measure is taken to check the progress of the gullies, they extend with destructive effect at a rapid rate.

A watershed survey made in 1932 by the Southern Forest Experiment Station within the East Gulf drainages indicated widespread occurrence of erosion. In the piedmont section of the Altamaha River drainage 32 percent of the area was found to be eroded. In the central portion of the Apalachicola River Basin 24 percent of the area examined was found to be eroded. This was almost entirely crop land, pasture land, and abandoned farm land. In the Apalachicola drainage as a whole 15 percent of the piedmont and 12 percent of the coastal plain was found to be undergoing erosion. In the other basins similar conditions obtain. The total area of land on which erosion was markedly noticeable was estimated at about 1,000,000 acres in the Alabama River drainage, about 2,000,000 acres in the Apalachicola River Basin, and more than half a million acres in the Tombigbee River Basin.

Erosion on such a large scale results in deposits of soil where they are not wanted. The Dunlap Dam (Gainesville, Ga.), with a pond area of 350 acres, was completed in 1904. The drainage area is 483 square miles. In 26 years the reservoir was almost completely silted, the volume of silt deposit being estimated at 5,250 acre-feet, or 202 acre-feet a year. The original pond area of 700 acres behind the Morgan Falls Dam near Atlanta, also completed in 1904, has been completely silted. The silt deposit here is estimated at 16,800 acre-feet, or 646 acre-feet a year, for a watershed of 1,390 square miles. Some 35,000 acre-feet of silt in 18 years has been deposited behind the Goat Rock Dam at Columbus, Ga., from a drainage area of 4,530 square miles. The North Highlands Dam at Columbus and the New Bridge Dam on the Chestatee branch of the Chattahoochee have been silted to the limit. On the basis of silting studies carried on by Army engineers it is estimated that silting in reservoirs on the Chattahoochee River may be expected to progress at the rate of 45 acre-feet annually for each square mile of catchment area. Large deposits of eroded material have been deposited on flooded bottom lands, in some instances ruining fertile lands for further agricultural use. The Bureau of Chemistry and Soils reports some 9,000 acres of bottom lands in Stewart County, Ga., to have been thus ruined.

As erosion on agricultural lands proceeds, abandonment takes place. The control of erosion on abandoned land is in considerable part a forest problem. Deeply gullied lands, according to Bennett, probably cannot be reclaimed for crops without centuries of soil building. Much land in this condition will restock naturally to pines. Where the stiff clay subsoil has been exposed, however, it is at least questionable whether a stand sufficiently dense to control rapid run-off and erosion can develop without artificial aid and some special measures to control erosion. On probably one third and possibly one half of the lands needing planting, conditions are so critical that special erosion-control measures will be necessary if planting is to be successful and erosion is to be controlled. These will include check dams, the plowing of gullies, and perhaps even the use of sod to hold the soil in place until tree growth has become established. Certainly planting of a large area is justified to halt erosion as quickly as possible, if for no other reason than to stop soil wastage.

Data are lacking as to the extent to which forest areas are eroded as contrasted with areas that have been in agriculture. The survey by the Southern Forest Experiment Station just referred to disclosed no forest areas where serious erosion existed. Undoubtedly some erosion occurs on forest areas, especially after fire and cutting, but in contrast with that on agricultural lands it is so slight as not to call for mention.

SUMMARY AND CONCLUSIONS

The most critical watershed situation in the East Gulf drainages is in the piedmont and upper coastal plain, where mismanagement of agricultural lands has brought about widespread erosion and changed stream conditions. Abandonment of agricultural land is proceeding on a large scale. Although some of the abandoned lands will restock naturally with forest growth in a few years, it is estimated that about a million acres of watershed land needs artificial reforestation. Planting alone will not be enough; on probably one third and possibly one half of the lands needing planting, special erosion-control measures will be needed.

In the highland area, land clearing has resulted in so much erosion that it should not be permitted to continue on the steeper slopes.

On private forest lands, lack of management is reflected in understocking due largely to fire and cutting. Fire control probably would bring about better watershed conditions more quickly than any other possible measure.

Where cutting and pasturage practices have led to watershed deterioration they should be modified. If these practices cannot be changed on certain critical areas through education of the timberland owners and operators, these areas should be brought into public ownership. The present condition of unmanaged private lands in the highlands as contrasted with that of managed national-forest lands suggests that there should be a material expansion of the present public forest enterprise.

In the highland and piedmont sections, where erosion has reached a critical stage on some 4.6 million acres of abandoned agricultural land, there is need for some form of public control or for public ownership. The large area of forest land having a major influence on streamflow and erosion, 15.4 million acres, should be similarly handled. Only through good management can the streams whose regimen has been so seriously upset by man's activities, be restored to their former condition. Shrinkage of the tax base of the counties, and difficulties experienced by local governments in financing forestry enterprises and bringing about fire control, suggest that local political units can not go far by themselves.

Investigations are needed locally to determine how watershed conditions are affected by the forest cover, to what extent good conditions can be preserved through forestry practices and what special measures are needed.

WEST GULF DRAINAGES

The watersheds of the West Gulf drainages comprise, in the aggregate, an area of approximately 124 million acres. The basin includes all of the streams in western Louisiana, and, with the exception of the Rio Grande and Pecos Rivers, all the main drainages in Texas (fig. 6). The principal streams are the Sabine, Trinity, Brazos, and Colorado Rivers. The extreme variations in climate, soils, and vegetation throughout this extensive area have had a correspondingly profound effect on land utilization as well as on watershed conditions.

CLIMATE IN RELATION TO WATERSHED PROBLEMS

Precipitation on these drainages comes almost entirely in the form of rainfall the rains varying tremendously in different portions of the basin. In the humid region of eastern Texas and western Louisiana the rainfall averages 50 to 60 inches annually as compared with about 15 inches in the arid region of western Texas. In the latter region evaporation rates are high and this tends to decrease further the supply of moisture available for plant growth. However, a tendency to torrential rainfalls in some portions of the basin makes annual averages unreliable indexes of true rainfall conditions, as in central and western Texas where a single heavy rain may account for as much as two thirds of the average annual precipitation. In eastern Texas and in the Gulf region intense rains are also common but they seldom reach cloudburst proportions. The maximum rain recorded in the Trinity River watershed is 5½ inches an hour and over 10 inches in 24 consecutive hours.

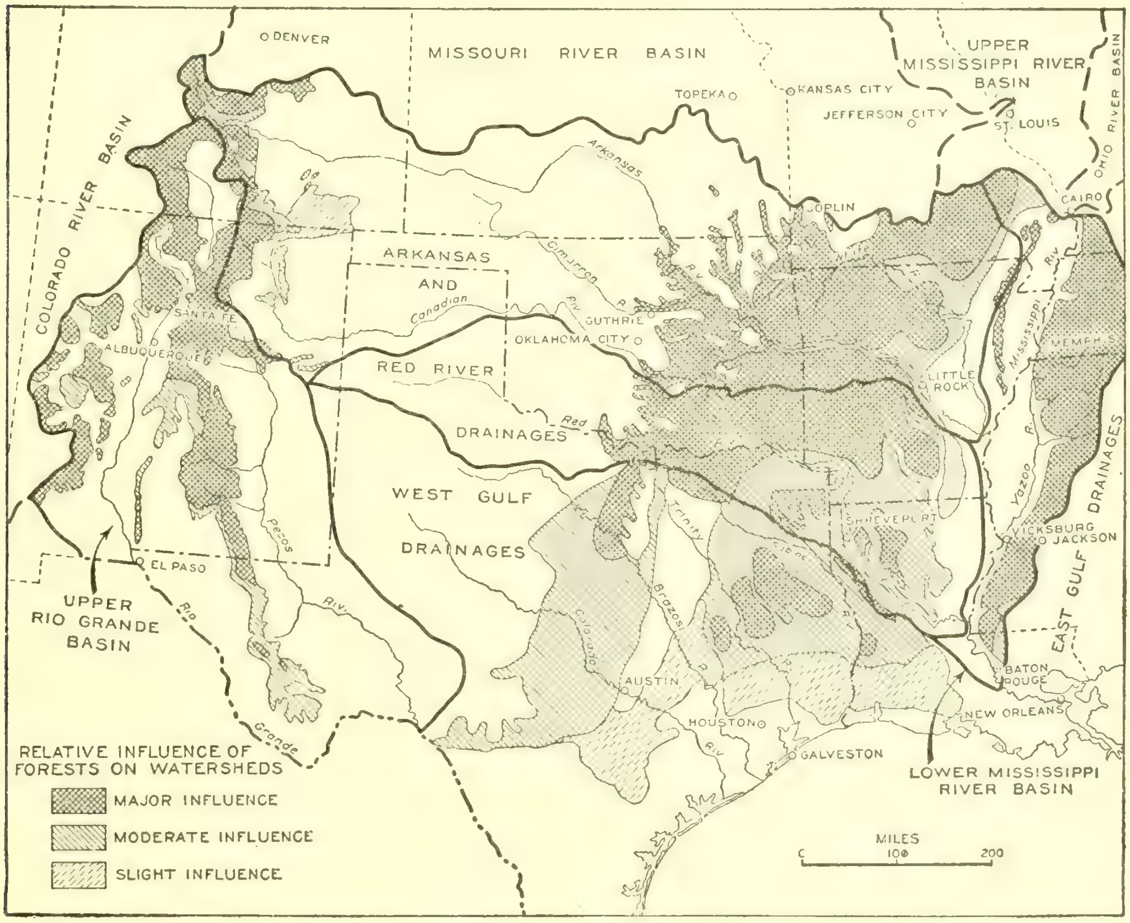
DENVER
MISSOURI RIVER BASIN
UPPER MISSISSIPPI RIVER BASIN
OHIO RIVER BASIN
TOPEKA
KANSAS CITY
JEFFERSON CITY
ST. LOUIS
CAIRO
COLORADO RIVER BASIN
Arkansas
JOPLIN
ARKANSAS AND RED RIVER DRAINAGES
Cimarron R.
Canadian
GUTHRIE
OKLAHOMA CITY
SANTA FE
ALBUQUERQUE
LITTLE ROCK
Mississippi R.
MEMPHIS
Red
WEST GULF DRAINAGES
Trinity
Brazos
Pecos
Yazoo R.
SHREVEPORT
VICKSBURG
JACKSON
EAST GULF DRAINAGES
EL PASO
Rio Grande
UPPER RIO GRANDE BASIN
Colorado
AUSTIN
HOUSTON
GALVESTON
BATON ROUGE
NEW ORLEANS
LOWER MISSISSIPPI RIVER BASIN
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
▩ MAJOR INFLUENCE
▨ MODERATE INFLUENCE
▧ SLIGHT INFLUENCE
MILES
0 100 200

Figure 6.—West Gulf drainages, Arkansas—Red River drainages, upper Rio Grande Basin and lower Mississippi River Basin.

The fact that these torrential rains are most frequent during the winter when pasture and range are least protected and cultivated lands are totally unprotected has an important influence in promoting a high run-off ratio. This in turn is reflected in floods, soil erosion, and decreased ground water supplies, especially in the more arid and sparsely vegetated portions of the basin.

STREAMFLOW PROBLEMS

CHARACTER OF FLOW

The streams of the basin are in the main perennial. In western Texas the headwater tributaries of the Brazos and Colorado Rivers are, however, dry for large portions of the year. The greatest range in flow is found in arid regions of torrential rainfall in central and western Texas. According to records of the Geological Survey the Little River, a tributary of the Brazos, had a maximum daily flow over a 14-year period of 647,000 second-feet and a minimum flow of only 3 second-feet. The Brazos River at Mineral Wells, Tex., has been completely dry on several occasions during the last 6 years and has had a maximum daily flow of 95,600 second-feet. The Colorado River at Austin, Tex., has varied over a 32-year period from 151,000 to 13 second-feet.

On the other hand, the Sabine River, draining a catchment basin having heavy rainfall and forests covering approximately 43 percent of the total area, fluctuates far less than the streams draining more arid contry, varying over a 6-year period at Ruliff, from 61,200 to 372 second-feet.

FLOODS

Floods are relatively common in all the drainages. In the Brazos and Colorado River drainages in central and western Texas, severe floods have been occurring at least once in a decade, caused as a rule by local rains of high intensity and rendered doubly destructive because of the lack of an adequate cover on the watersheds. The flood of 1900 caused the failure of the Austin Dam on the Colorado River and flooded large areas of bottomland from Austin to the Gulf. The Brazos flood of September 1921 is reported to have cost the lives of 164 people and damaged property to the extent of more than $12,000,000.

Floods are even more common in the Trinity River drainage, occurring most frequently during spring and fall. According to Weather Bureau records, overflows in the vicinity of Dallas, Tex., have averaged about 4 a year during the last 8 years, and the Trinity River at Trinidad, Tex., has been at flood 33 times in the last 8 years. Both of the above stations are located in the black waxy belt—a region of heavy but productive soils practically all of which are in cultivation. On the Sabine River floods occur almost annually, but they are seldom general throughout the drainage and are most frequent during the winter months as the result of heavy rains of rather local occurrence.

STREAM-FLOW UTILIZATION

The streams of the West Gulf Basin are and apparently must be relatively unimportant for navigation and the development of hydroelectric power, owing largely to uncertain flow and heavy silt loads.

Water supplies for domestic use and irrigation are reported to be critically low in the arid portions of the basin. Irrigation is locally important on the Nueces and Concho Rivers and to a minor extent for rice growing near the mouth of the Sabine-Neches drainage.

SILTING OF CHANNELS

The streams of the west Gulf Basin are normally clear but during periods of flood carry enormous quantities of soil eroded from the watersheds. Ashe [33] states that the silt burden of the Colorado River is roughly estimated at 1 percent of its volume or an average of 18,000 acre-feet a year; and that the Brazos River, above Waco, with a drainage area of 30,000 square miles, carries more than 3,200,000 tons of soil a year. Records of measurements made in the Brazos River at Rosenberg over an 8-year period by the United States Bureau of Agricultural Engineering, cooperating with the Texas Board of Water Engineers, show that the maximum monthly silt load carried during a flood period by this river was the 20,000 acre-feet carried in May 1930.

Direct evidence of the economic significance of these silt loads are cited by Ashe who states that the ill-fated Austin Dam on the Colorado River, which broke after only 10 years of service, had its storage capacity reduced 56 percent as a result of silting. The new reservoir constructed in 1913 had by 1922 lost 84 percent of its capacity through silting.

Flood waters of the Trinity and Sabine Rivers are also quite muddy. The Trinity River has overflows known locally as "black floods" and "red floods", depending on whether the storm occurred in the black waxy belt or in the regions of predominantly red soils. These heavy soil loads are, however, considered by engineers to be much less than the huge quantities transported by the Colorado and Brazos Rivers.

EROSION PROBLEMS

Extremely active erosion of the badlands type is occurring in a region in northwestern Texas known as the "Breaks." This escarpment, between the high plains on the west and the red prairies of Edwards Plateau, varies in width from 1 to several miles and is intricately dissected by the headwater streams of the Colorado and Brazos Rivers with many steep and unstable slopes—the zone of active erosion extending out along the water courses into the red prairies.

In central Texas, along the border of the Edwards Plateau, standing 400 to 1,000 feet above the coastal plain, the streams have cut deep channels and have converted the original plateau edge into a ragged escarpment of mesas, buttes, and rocky canyons. In many places over an extensive area the relatively thin soil has been removed, leaving the parent rock exposed. Moisture conditions are not particularly favorable for tree growth, hence it is largely only where cool exposures exist or when a deep soil occurs that the forest is able to maintain itself. The stand is open and the woods frequently occur as merely scattering patches interrupted by grassy openings. In such locations, any marked disturbance to the cover results in erosion, which when once under way progresses for a considerable period before the vegetation can stop it. On steep slopes such erosion often continues unchecked by any possible vegetational control.

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[33] Ashe, W. W. Financial Limitation in the Employment of Forest Cover in Protecting Reservoirs. U.S.Dept.Agr.Bul. 1430, 1926.

In the eastern portion of the region and more particularly in the Trinity, Sabine, and Neches watersheds, cultivation has led to equally severe erosion. Extensive surveys by the Southern Forest Experiment Station indicate that erosion in these drainages is largely confined to areas in cultivation or to those worn out and abandoned. The data indicate that a million acres of such land is badly eroded, about one fourth of it in the black waxy belt and "cross-timbers" region, and three fourths within the upper coastal plain. In the upper coastal plain nearly 2 million acres of formerly arable land is now lying idle, and of this about 250,000 acres is barren and actively eroding.

The above estimates are undoubtedly very conservative since they take no account of sheet erosion on many of the cultivated fields. Experimental data obtained by the Bureau of Chemistry and Soils, the Texas Experiment Station, and other agencies have demonstrated that in the agricultural sections of Texas soil losses from very gentle slopes are enormous. Bennett[33a] states that at the Spur substation of the Texas Agricultural Experiment Station, in west Texas, 40.7 tons per acre of soil was removed from a 2 percent slope of fallow land by a total rainfall of approximately 27 inches. Gullying is by no means as rapid on these drainages as on similar land in the silt loam uplands of the lower Mississippi Basin. As a rule, gullies more than a few feet in depth are not common.

FORESTS OF THE WEST GULF DRAINAGES

CHARACTER AND EXTENT

The forest area of the west Gulf drainages is estimated as 36,736,000 acres, or about 30 percent of the gross area of the basin. Less than half of this consists of true forest, the remainder includes sparsely stocked areas of scrub oak, juniper, mesquite, and chaparral which predominate throughout the zone of meager tree growth in central and western Texas. The areas of commercial forest, made up of two major types—the longleaf pine and the shortleaf-loblolly hardwoods—occur entirely in the eastern part of the basin and are limited mostly to the upper coastal plain portion of the Sabine, Neches, and Trinity watersheds.

The long leaf pine forests, restricted almost entirely to the lower part of the Sabine drainage, have been so heavily cut over as to be practically denuded and to be restocking only very slowly if at all. Were this condition to exist in a region of steep slopes, at the head of important streams, the situation would be disastrous. Here, however, although run-off is probably greatly encouraged, the relatively level topography and the abundance of protective ground cover serve to hold the soil. The soils of the long leaf land are too low in fertility to be extensively cleared for agriculture. The National Forest Reservation Commission has approved the purchase of 24,575 acres of cut-over long leaf land in west central Louisiana, of which 17,965 acres have already been acquired.

The remainder of the commercial forest consists largely of upland stands made up of shortleaf or loblolly pines, or both, in mixture mainly with such hardwoods as mixed oaks and hickory. On alluvial bottom lands ash, sweet and black gum, magnolia, sycamore, and other moisture-loving species are included. Upland stands are seldom cut clear and an abundance of smaller trees and reproduction is customarily left. Cut-over areas within the range of the pines restock at a very rapid rate as a rule. Large areas of the pine-hardwood lands cleared for agriculture have been abandoned because of erosion, but observations indicate that many old fields are taken over within 5 or 10 years by shortleaf and loblolly pine reproduction which tends to check gullying and to heal lesser forms of erosion.

[33a] Bennett, H. H., and Chapline, W. R. Soil Erosion a National Menace. U.S.Dept.Agr.Circ. 33, 1928.

More than half of the commercial forest area is unprotected from fire and an average of 865,944 acres of this area, largely in long leaf pine, was burned over annually during the years 1926 to 1930 inclusive. These ground fires, usually set by livestock owners during the winter season, destroy the forest litter and are so frequent as to prevent the accumulation of duff and other surface debris, thereby lessening the protective efficiency of the forest cover.

In the Edwards Plateau and "cross-timber" regions of west central Texas the predominant cover consists of scrub oaks, juniper, elm, hackberry, and other species, except along the water courses, where elm, cottonwood, sycamore, and other water-demanding species tend toward luxuriant growth. Toward the west, the scrub species give way to mesquite and shrubs which merge into the grassland of the prairies and high plains of western Texas.

The scrub forests of the plateau region are seldom cut extensively, although they are an important source of firewood, fence posts, and other products for local use. The heaviest inroads have been made in the cedar stands. The scrub oak and juniper stands as a rule do not form a continuous forest but often occur as scattering woodland interspersed by areas of grassland which, particularly those in the western portion of the plateau, furnish range for large herds of livestock. Heavy and unregulated grazing, the rather thin soils of the region, and the lack of adequate rainfall all combine to keep ground cover in a rather depleted condition. Bray[34] describes the transition from former prairie to scrub-oak woodland that has occurred in this region as the result of overgrazing and a decrease in the number of fires. He also cites the spread of mesquite and shrubs over cattle country in central Texas.

According to Bray, fires have become relatively infrequent throughout the Edwards Plateau since settlement of the country, but during dry seasons they occasionally do considerable damage to juniper stands.

RELATION TO WATERSHED PROBLEM

Experimental studies carried out in northern Mississippi by the Forest Service point to the influence of similar forest cover on the west Gulf drainages in preventing surface run-off and regulating stream flow. Data obtained in 1932 in the upland watersheds of the Yazoo River during a flood period show that less than 0.5 percent of 27 inches of rain falling on an undisturbed oak forest ran off the surface while 62 percent ran off a cultivated field. Other data obtained in May 1930 by the United States Bureau of Chemistry and Soils in the fringe forests of Oklahoma show that surface run-off from burned scrub-oak woodland was 110 times that from a comparable unburned area. In the light of these studies it would seem that similar forest in the west Gulf Basin would exercise a like influence.

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[34] Bray, W. L. The Timber of the Edwards Plateau of Texas. U.S. Dept. Agr. Forestry Bul. 49, 1904.

Of the total forest area of some 37 million acres, about 3 million acres is classed as exerting a major influence on watersheds (fig. 6). In east Texas the highly protective forests consist of rather well-stocked stands made up mostly of shortleaf pine and mixed oaks and other hardwoods. They occur on hilly portions of the upper coastal plain where the heavy and rather erosive clay soils and hilly topography tend to limit the absorption of rainfall and make for a high run-off ratio. Approximately 2 million acres of this protection class occurs in the Sabine and Trinity drainages. In west Texas the forest exerting a major protection influence is the sparse woodland largely in the Breaks region where a cover is essential to stable soils and to decreased flood run-off. It is felt that if more were known of this region, a much larger area would be classed as having a major influence.

Roughly, 21 million acres of forest are classed as having a moderate influence on watersheds. This class includes not only the well-stocked stands of pine-hardwoods in the coastal plain portion of the Trinity and Sabine drainages but also the more extensive scrub oak forests of central Texas.

About 11 million acres of forest in regions of mild topography where the soils are little subject to erosion and surface drainage is not excessive are classed as having only a slight influence on watersheds. They occur in the lower portions of the main drainages, i.e., in the interior flatwoods, coastal prairies, and the more level portions of the upper coastal plain. Another 2 million acres of forest located on alluvial bottom lands are classed as having no influence on watersheds, though some of them are beneficial in holding the stream banks against erosion.

WATERSHED NEEDS

In general, watershed conditions throughout the West Gulf Basin are far from satisfactory. The prevalence of floods, the inadequacy of water supplies in certain sections, and the extent of erosion all indicate that present vegetative cover is not adequate. The forests are too open, litter is absent, the forest is returning but slowly to denuded lands, and the ground cover is badly depleted.

Of the forestry measures aimed at improving watershed conditions it appears probable that the establishment of new forests will play a minor part. The data collected by the Forest Service in 1932 indicate that of approximately 2,775,000 acres of abandoned fields in the eastern half of the region where climatic conditions permit the growing of commercial forests, about 1,250,000 acres are seriously eroding. However, a very large part of this land is in the upper coastal plain where, given protection, tree reproduction and other native vegetation can be depended on to reclothe the land rather quickly and to check erosion within a few years. Reforestation is needed, however, on about 250,000 acres of badly eroded land. On the remaining abandoned lands some kind of vegetation has already become established. This is serving to hold the soil and, if protected from fire, a forest will gradually take possession and develop more favorable conditions of stream flow.

Improving present forest cover, however, offers a considerable opportunity for combating the watershed problems of portions of the basin. Fire protection on some 8 million acres of unprotected commercial forests would promote the accumulation of forest litter and other ground cover. The extensive scrub forests of central Texas and of the "Breaks" region are, however, in greatest need of improvement. Here fire protection and probably less cutting would do much to encourage scrub oak, mesquite, and other chaparral species. A number of authorities have commented on the deleterious effects of the heavy grazing in this region as contributing to the depletion of the original grass cover. Proper management of livestock to prevent overgrazing, therefore, appears to be the outstanding requirement for improved watershed protection.

In view of the fact that most of this land is in private ownership and that the private owners probably will be financially unable to adopt those corrective measures for the eroded abandoned land which will make for the control of erosion and favorable conditions of stream flow, public ownership appears needed. This ownership should include about 2,300,000 acres of land in those parts of the region where watershed conditions are most critical and where the forest cover exerts a major influence. This would mean about 400,000 acres of abandoned agricultural land and about 1,900,000 acres of forest land. However, as cover conditions and watershed relationships in the West Gulf drainages are imperfectly known, it is more than likely that a much larger area should be in the hands of the public. The lack of specific information as to erosion-control methods indicates that investigations are needed and that these are particularly necessary in the "Breaks" region.

ST. LAWRENCE RIVER BASIN

The St. Lawrence River (or Great Lakes) drainage in the United States amounts to nearly 85 million acres, of which about 50 percent is forest land. The western portion of this basin is shown in the map of the upper Mississippi River Basin, figure 7; the eastern is shown with the northeastern drainages in figure 3. The forest areas of the basin are classified according to watershed-protective influence as follows: Major influence, 5,029,000 acres; moderate influence, 4,112,000 acres; slight or no influence, 33,105,000 acres.

The relative slightness of forest influence on watersheds in this drainage is more marked in the western half than in the eastern. It is due largely to the fact that much of the St. Lawrence drainage has been heavily glaciated and that large parts of it, particularly in the west, are without marked topographic relief. Throughout many parts of the drainage occur the gravelly and sandy hills and rolling lands typical of glaciated regions. Extensive areas of outwash plains occur, the sandy soils of which are highly absorptive.

The comparative uniformity of the water level in the Great Lakes is due to the very large areas of water and of absorptive soil surface in the drainage rather than to the influence of forest cover. Water supplies are ample. On certain areas in the drainage, however, from a watershed standpoint, a forest cover is necessary.

DUNE LANDS

Dunes occupy only a narrow strip of land along the eastern shore of the Great Lakes. In many places the width of this strip is scarcely half a mile; in some it is as much as 10 miles. The area involved is probably not more than 125,000 acres. Locally, however, the dunes do considerable harm. As they migrate eastward under the prevailing westerly winds they become a constantly increasing menace to tillable lands and to improvements. They have invaded factory yards in Gary, Ind., and have repeatedly encroached upon railroads and highways.

Usually a scattered stand of oaks or a low, shrubby vegetation occurs on the dunes. Where this cover is complete, it holds the sand in place. Cutting, fire, and trampling by recreationists have so deteriorated the cover that many of the dunes, formerly stable, are now in motion.

A problem akin to that of the shore dunes has developed in New York west of the Adirondack Mountains. As a result of cultivation the top soil has eroded away, exposing fine sand. Unless held in place by a plant cover, this sand moves easily with the wind and in places forms inland dunes. The uncovering of this sand and its movement have led to abandonment of agricultural land which according to census data has caused the area of crop land in these counties to decrease by from 10 to 20 percent. Undoubtedly this condition has been responsible for a considerable part of the farm-land abandonment in St. Lawrence, Lewis, Oswego, and Jefferson Counties. In an effort to control this soil movement the State of New York has purchased many abandoned farms and is reforesting them.

MOUNTAIN AREAS

The roughest lands in the St. Lawrence drainage are in the Adirondacks and the Green Mountains. Here heavy precipitation, steep slopes, and heavy soils make for rapid run-off and for erosion from cleared lands. For the most part these mountains sustain a hardwood and spruce forest that protects the soil.

On State lands in the Adirondack State Park good cover conditions are safeguarded by a constitutional prohibition of timber cutting. Areas in private ownership within the park, however, are subject to cutting. On these the present selective cutting, winter logging, and infrequent fires disturb the soil but slightly. The land cut over is soon reclaimed by hardwood sprouts. Poor cover conditions brought about by earlier over cutting and by heavy summer fires are gradually improving under fire protection. The State plans to acquire additional lands within the park area.

In the Green Mountains, with their more rolling terrain, a larger area has been brought under cultivation than in the Adirondacks. Abandonment of cultivated lands is common, owing in part to sheet erosion of the heavy soils. In the hardwood stands logging and other disturbances are not destructive. Much of the cutting is done by farmers in the winter, the fire hazard is low except for dry grass in abandoned fields, and there is little grazing on forest lands. On no class of forest land does the forest cover have difficulty in reestablishing itself except on abandoned agricultural land.

OTHER AREAS

Elsewhere in the St. Lawrence drainage, rather localized problems exist. In the drainage to Lake Ontario in New York and to Lake Erie in northeastern Ohio, erosion is taking place on cultivated lands and local floods occasionally do damage. On areas that have not been cleared for agriculture, the cover is usually sufficient to hold the soil and to maintain favorable conditions of water flow. Cutting has little disturbing effect on the cover, because of the sprouting capacity of the hardwoods, and serious fires and extensive overgrazing are in general absent. On abandoned farm lands the forest has great difficulty in reestablishing itself naturally.

The most wide-spread type of erosion, although probably the least recognized, is slow sheet erosion on the soils of the Volusia series. This is particularly severe on the cleared hill lands of western New York, and is common also in northeastern Ohio. Studies by Professor Barron and associated pasture specialists, of Cornell Univesity, indicate that on these soils sheet erosion, acting since the land was first cleared, is an important factor in decreasing soil fertility and leading to land abandonment. On many hill farms sheet erosion manifests itself in an increasingly stony condition of the surface as the finer top soil is gradually washed away. In extreme cases the surface soil of the steeper slopes, largely in pastures, becomes too shallow for further cultivation.

In a study made by G. R. Stewart at Cornell University, the permeability of fertile hardwood forest soil was compared with that of run-down pastures on the same soil types. The forest soils were found to be more permeable to water and more retentive of water. All grass lands compared with the best forest soil showed a poorer physical condition. The greatest difference was shown by the run-down poverty-grass pastures located on the compact Volusia soils. Here water passed into the soil very slowly. It is on such compact soils that much farm abandonment occurs. Census data show marked decline in the past two decades in the crop land of Ashtabula, Geauga, Trumbull, Summit, and other counties in Ohio, in Erie and Crawford Counties in Pennsylvania, and Chautauqua County in New York. Compact soils are general in these counties.

Another type of erosion on agricultural lands takes place on the deeper soils. This consists of sudden breaks or gullies that may form in a few days' time when the top soil is fairly well saturated with water, as in the early spring. It is especially marked on the steeper hillsides. This more serious erosion, according to Professor Barron, probably grows out of sheet erosion and a decrease in the fertility of the soil. It is reflected in a poor growth of grass in the spring. The thin sod is easily broken by cattle and a small gully, once formed, grows rapidly. Such gullying was found by the Northeastern Forest Experiment Station to be not at all uncommon in the Genesee River Valley, from the headwaters of the river to the lower levels adjacent to Conesus Lake. Gullies of this type combine and grow steadily in each season of heavy rainfall. A decline of from 15 to 20 percent in crop land, reflecting this situation, is shown by census data for such New York counties as Genesee, Wyoming, Cattaraugus, and Allegheny. New York State has taken a positive step toward bettering conditions on eroded lands by acquiring and reforesting such lands. New York municipalities, also, have acquired lands on the watersheds from which they obtain their water supplies and planted them with trees. At the rate at which public ownership and management are now progressing, however, many years would be required to bring about good forest cover conditions on all the abandoned agricultural lands in this drainage that have watershed-protection value.

In the western part of the St. Lawrence drainage, although forest depletion is extensive, no serious erosion or watershed troubles have been reported. In the upper peninsula of Michigan and along the north shore of Lake Superior a complete forest cover prevents erosion. Here the slopes are steeper than in many other sections of the Great Lakes region and deforestation would lead to rapid run-off and severe erosion.

SUMMARY

Although the forest lands of the St. Lawrence drainage, except in the Adirondack State Park, are in poor shape from the standpoint of commercial forestry, because of cutting and fire in the past, yet these forest lands are not in a serious condition from the standpoint of watershed protection. Some areas, such as the sand dunes, will require special treatment if erosion is to be stopped, but in general rather simple measures of forest management and fire control will meet the objectives of watershed protection. Estimates indicate that about 500,000 acres are in need of planting, and about 50,000 acres are in need of some special form of treatment to help stabilize the soil.

The present survey of existing conditions shows that in the region of major influence, an additional area of about 1 million acres should be in some form of public ownership. About 300,000 acres of the total are the abandoned agricultural lands, and 700,000 acres are other forest lands. Just what form this ownership should take, whether national, State, or local, depends upon the interest and ability of the agency involved.

HUDSON BAY DRAINAGES

The drainage to Hudson Bay includes some 40,000 square miles of land in northern Minnesota and North and South Dakota, practically all of which is drained by the Red River of the North and its tributaries (fig. 10). The Red River is a lazy, meandering prairie stream that winds through a broad agricultural valley, the terrain of which is without notable relief.

About 25 percent of the Hudson Bay drainage can be considered forest land. By far the larger part of this is in Minnesota, where the prairie transition forest appears at a distance of from 30 to 50 miles from the river, on the first important rise of ground. The outer fringe of the transition forest is of bur oak and associated prairie tree species. At greater distances from the river occur swamp forests, once principally of spruce. By reason of cutting and fires, the spruce has largely given way to aspen. Not much pine is present except on the better-drained soils toward the eastern edge of the drainage. Open oak forests again appear on the Pembina and Turtle Mountains in North Dakota, on the international boundary. On the sandier soils of North Dakota, such as the uplands about Devils Lake, and along the streams, occur some severely culled small forests.

The small quantity of forest along the stream courses and the small scattered areas of upland forest in North Dakota are insufficient to have much effect on the flow of the Red River. They are important in preventing erosion. Some erosion has followed cutting on the Pembina and Turtle Mountains in North Dakota, but it is of little consequence except very locally. Recreational use, which would preserve watershed values, might conceivably be the best use for this hill land, because of the absence of nearby recreation areas on the American side and because the Canadian half of the Turtle Mountains is managed for recreation.

Some of the spruce forest swamp areas in Minnesota have been drained for agricultural use, but increasing abandonment of cleared lands indicates that these areas are probably submarginal for agriculture. As the ditches become clogged following disuse, the forest is gradually taking possession again.

In the Red River Valley windbreaks and shelterbelts have been planted about farm buildings. Their aggregate area is not large, and they have little, if any, bearing on stream conditions. Further tree planting, desirable from the standpoint of farm comfort, would have little if any effect upon the streams.

UPPER MISSISSIPPI RIVER BASIN

The upper Mississippi River Basin is that portion of the area north of the Ohio that drains into the main river. It includes some 15 percent of the entire Mississippi drainage system. It is divided roughly in two by a line running in a northwest and southeast direction through Minnesota approximately at St. Paul and so continuing through Wisconsin. In the present discussion the two divisions will be referred to as the northern or heavily glaciated area and the southern or silt loam uplands area.

Both areas have been severely glaciated, first by ice sheets that extended as far south as the Missouri and Ohio Rivers and later by the Wisconsin stages, which reached central and southeastern Wisconsin and central Minnesota. The earlier glacial soils are largely till, in which clays predominate. Silt loams are common in the old lake beds. The Wisconsin advance was so recent that the topography, drainage, and soils of the deposit have been but little modified. Consequently sands and gravels predominate, although clay deposits have covered some of the sand. In the older glaciation, the land is for the most part level or gently rolling. In the northern area are pronounced moraines and drumlins, some of them sufficiently prominent to form the divides between such Wisconsin rivers as the Chippewa, Black, Wisconsin, and St. Croix.

On the areas more recently glaciated the sandy soils support a pine forest and the heavier soils support hardwood stands in which beech, maple, elm, and ash are common. The swamps, some of which are of considerable size, contain spruce, fir, cedar, and tamarack. The heavier soils of the older glaciation having weathered and leached more, support oaks, hickories, walnuts, and other typical upland species.

A small area escaped glaciation. This driftless area lies chiefly in southwestern Wisconsin, and extends into Illinois, Iowa, and Minnesota. Here the deep soils, derived from parent rock, are highly erosible. This old plain was thoroughly dissected by normal erosion probably even before the advance of the ice on neighboring areas.

Deposits of loess are a distinctive feature of the upper Mississippi Basin. These are found for the most part east of the Mississippi River, though extensive deposits are found also in Iowa and Missouri. The loess is thick about the terminals of the ice sheets in northeastern Iowa and southern Illinois. Away from these borders it thins out on interstream areas, although it retains its thickness along the larger valleys. It occurs commonly on bluffs immediately overlooking the valleys. Under a vegetative cover it is very porous and absorptive. On this loess soil oaks and other upland species predominate.

These physiographic features are largely responsible for the watershed-protective classification given the forest area of the upper Mississippi River Basin. Of the total 28 million acres only slightly more than 10 million acres is classed as having a considerable measure of influence upon watershed conditions. The lands so classed occur principally in the southern half of the basin, on loess areas and driftless areas and in the uplands of the older glaciation. In the northern division, the areas of greatest influence upon watershed conditions lie in the large moraines at the head of the Chippewa River. Some 5,700,000 acres of forest is classed as having a major watershed-protective influence, and 4,430,000 acres as having a moderate influence. The remaining area is considered to have relatively slight influence largely because of the absorptive nature of the soil and the presence of numerous lakes and swamps. The areas ascribed to each class are shown in figure 7.

The average annual precipitation totals 25 to 30 inches in Minnesota, 30 to 35 inches over the Wisconsin portion of the basin, and more than 35 inches in some parts of Illinois. Most of the precipitation occurs during the spring and summer months. Snowfall averages between 40 and 60 inches in the north, and from 20 to 30 inches in the south. Rainfall of more than 1 inch in 24 hours sometimes occurs four times in a single year in the northern part. In the southern part, 24-hour rainfall exceeds 1 inch still more frequently, exceeds 2 inches as often as once a year, and has been known to total 4 inches.

Local floods are not uncommon. In the north, "freshets" rather than major floods occur. Occasionally severe floods occur in the southern streams as a result of rapid snow melt. The high percentage of cleared land is a factor in these floods, because so much of the cultivated land is without a cover crop during early spring.

HEAVILY GLACIATED REGION

In the heavily glaciated region the character of the terrain and soils makes for low run-off. In much of the region hills are either of gentle slope or largely of gravel. Outwash sand plains are comparatively flat. The sands provide a large absorbing surface, and much of the land characterized by heavier soils is poorly drained. The stream-flow regulation effected by the many swamps and lakes is supplemented by artificial reservoirs.

Forest conditions have greatly changed in the last century. Settlement, which began in the prairies and in the scattered oak forests of southern Wisconsin, gradually spread northward and westward into the more densely forested areas. Extensive tracts were cleared and put into cultivation. Timber cutting followed closely upon agricultural development. So far has the removal of the old-growth timber progressed that almost any tree that will saw out a board is marketable.

Cutting has not been solely responsible for the change in the forest cover; fires have been common and extensive. On the cut-over areas fires destroyed what timber was left after logging. Fires have occurred repeatedly on many of the cut-over areas, making conditions even more unfavorable to future forest growth.

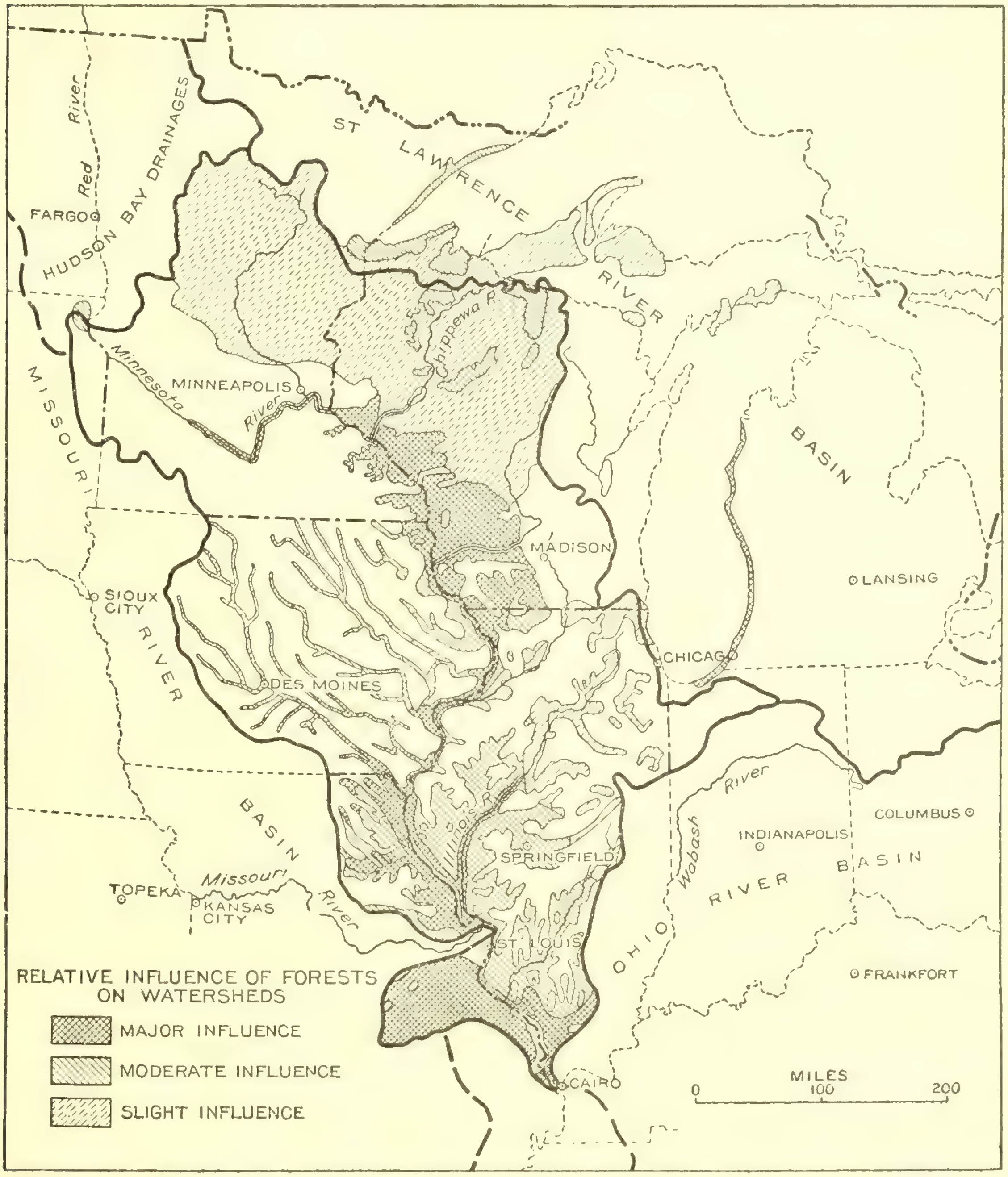
Red River
HUDSON BAY DRAINAGES
ST LAWRENCE RIVER
FARGO
Chippewa R.
MINNEAPOLIS
Minnesota River
MISSOURI
BASIN
MADISON
LANSING
SIOUX CITY
RIVER
CHICAGO
DES MOINES
River
Wabash
INDIANAPOLIS
COLUMBUS
BASIN
BASIN
SPRINGFIELD
RIVER
TOPEKA
Missouri River
KANSAS CITY
ST LOUIS
OHIO
FRANKFORT
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
CAIRO
MILES
0
100
200

FIGURE 7.—Upper Mississippi River Basin and upper portion of St. Lawrence River Basin.

The conifer forest, destroyed by fire and cutting, has been replaced by such cover types as sweet fern, brush, aspen, fire cherry, or birch. On some areas an oak woodland type has developed, and on others with sandier soil a jack pine woodland has appeared.

Because the soils at the headwaters of the Mississippi are for the most part very porous, it is possible that even the destruction of the humus has not materially changed their capacity to absorb and hold water.

Although cutting and fire have depleted the hardwood forests, regrowth has taken place rather promptly. When the mature forest has been destroyed, coppice and other new growth have taken possession. Hardwood litter helps to increase soil fertility and porosity. On hardwood areas, particularly in the rather rough country at the head of the Chippewa River, the forest cover prevents erosion of the fine soil that would easily be floated away.

SILT LOAM UPLANDS

Only about half the upland area was originally occupied by forests. The most extensive of these forests were in southwestern Wisconsin and northwestern Illinois, and in southern Illinois and southeastern Missouri. The others existed as scattered areas of woodland in the prairies and in the bottom lands. Toward its western edge the basin was practically treeless.

Some of the forests were exploited commercially. In the lead region of northwestern Illinois and in the limestone areas, extensive fuel-wood cuttings were made. Commercial timber production for other than local needs prevailed in the bottoms, particularly in southern Illinois. Although fires were a usual concomitant of cutting, devastation was prevented by the fact that the forests were largely of hardwoods which sprouted.

In the prairie region, small areas of the scattered original forests remained as farm woodlands. These have been repeatedly culled and most of them have been pastured. Culling has left only the poorest trees, and in many instances pasturage has grown so heavy as to prevent tree reproduction.

The upland soils were very fertile and very absorptive when first put under cultivation, because of the accumulations of organic matter. Agriculture gradually exhausted the humic deposits. Sheet erosion increased as the humus was dissipated. On the hilly lands it soon developed into small shoestring gullies, and these rapidly grew into more serious gullies.

Severe gullying took place wherever water collecting on the plateau lands ran over the bluffs. It has now gone so far that on many hill lands it prevents the farmers from reaching some of their fields with farm equipment.

INFLUENCE OF FOREST COVER ON WATERSHED CONDITIONS

Because the silt loam soils of the uplands are eroded so easily when bare, the forest cover on them is classed as having a major watershed-protective influence. That a forest cover maintains favorable conditions of water flow on these upland soils is shown by observations of the Lake States Forest Experiment Station as to run-off from summer rains in southwestern Wisconsin.[35] Data from these investigations show that the run-off from pastures that have been cleared, plowed, and seeded, as well as from areas in timothy, clover, or alfalfa, is approximately the same as that from cultivated fields. Seeded pastures, because of close cropping, packing of soil, and slopes generally steeper than those prevailing in fields, were the largest contributors to run-off.

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[35] Bates, C. G., and Zeasman, O. R., Soil Erosion, Wisc.Agri.Expt.Sta.Res.Bul. 99, 1930.

Not only did the timbered lands produce a negligible run-off but there was no erosion from such areas.

As shown in these investigations, the effectiveness of forest stands of different densities in holding back run-off on these uplands varies materially with density of stand and intensity of grazing.

BEHAVIOR OF SMALL STREAMS

Although reliable quantitative measurements on intermittent small streams are unavailable, field observations indicate that those originating on field and pasture areas may yield 50 percent or more run-off from hard rains. Thus a watershed of 100 acres may readily develop a stream the peak flow of which exceeds 100 second-feet. It would be virtually impossible for such a flow to be developed by an area having a complete forest cover.

Of greater interest is the behavior of permanent small streams draining watersheds so small that the entire area is likely to be affected by a single local storm. A watershed area of 5,000 acres, for example, may deliver normally a stream of about 5 second-feet. Under extreme conditions such a stream may be swollen to 800 or more times its normal volume, developing a peak flow of 0.8 second-foot per acre of watershed. On larger watersheds, although under similar conditions the total flood volume may be proportionately the same, because of the greater length of stream and greater diversity of watershed conditions, there is a tendency for the flood to be relatively more prolonged and for the peak flow to be relatively lower.

The flashy run-off of the small streams is strikingly illustrated by Gilmore Creek, near Winona, Minn., having a watershed area of only about 15 square miles, of which about 40 percent has been cleared and having, under normal conditions, a discharge of 10 second-feet. During August 1932 the discharge of this stream rose in 2 hours to nearly 5,000 second-feet, sweeping everything in its path, including finally the concrete weir at which the discharge was measured. Such phenomena have not been infrequent in the history of this stream since the advent of agriculture.

SILT LOADS OF STREAMS

According to conservative estimates by the Lake States Forest Experiment Station based on sampling, the Wisconsin River carries 2 million cubic yards of silt, despite the fact that some of the load from the upper three fourths of its drainage now settles above power dams. A proportionate silt contribution from the Black River, on which conditions are similar, would probably be about 1 million cubic yards annually.

The smaller streams that rise within the unglaciated area are likewise heavily loaded with silt. Their contributions of water may never be large enough to affect appreciably the flow of the Mississippi, but they bring silt loads entirely disproportionate to their water discharges. Temporary streams that empty directly into the Mississippi often carry 5 to 10 percent of solid matter. Larger and more permanent streams such as the Buffalo River sometimes carry 5 percent of silt to their outlets.

EROSION OF AGRICULTURAL LANDS

Soil surveys recently made in the Central States by various State agencies have revealed some 17 million acres of badly eroded agricultural land on which the continuance of agriculture is at least doubtful under present conditions. Of this total something like 6 or 7 million acres lies in the upper Mississippi River drainage. On these lands farm abandonment is progressing.

The widespread occurrence of erosion is indicated by figure 8, based on data of the Illinois Soil Survey, which shows the extent and distribution of lands "destructively" and "seriously" eroded in Illinois. The field work which this map represents included sampling of every 10 acres. "Destructively eroded" areas are defined by Dr. A. E. Norton, assistant chief of the Illinois State Soil Survey, as "areas which cannot be cultivated by any practical known means at a profit because they erode faster than it is possible to build up the soil. * * *. Within this division there are areas suitable for pasturing, orcharding, and timbering. The percentage of the first two is relatively small in comparison with that suitable for timbering only." Dr. Norton defines "seriously eroded" lands as "areas which can be cultivated by specialized methods for profit. Certain treatment, such as terracing and the application of readily available organic matter, must be given the land before it can be cultivated. No doubt much of it could best be utilized in forests until such time as there is a greater demand for cultivated crops than at present." The Illinois Soil Survey recognizes a third class of eroded land: Harmfully eroded areas are subject to sheet erosion. Unless the methods of agriculture are changed in the future, "this area will some day fall in the destructive erosion division." Land of this class is not indicated on the map. The survey data show some 3 million acres of destructively eroding land, 3 million acres of seriously eroding land, and 12½ million acres of harmfully eroded land.

State soils specialists and State foresters have estimated that between 50 and 75 percent of the more severely eroded land in the upper Mississippi River basin has already been abandoned. Much of this land is almost completely denuded.

According to the results of investigations made by the Missouri Agricultural Experiment Station on loamy soils continuously in corn, a 7-inch layer of soil is removed in 49 years from tilled land that slopes 4 feet in 100. This is at the rate of 20.5 tons of soil per acre per year. It is possible that even greater soil losses have occurred on areas of loess soil such as those in southern Illinois.

In the driftless area, dairying has been extensively developed. There is every reason to believe that it has been overdeveloped. Too much land has been cleared, too large an area has been put into crops and pasture, too much trampling has taken place. Consequently gullying is making it impossible for the industry to continue on its present scale. Although only about one third of the total area cleared is being cultivated, areas under cultivation include much land with grades exceeding 20 percent and occasional slopes with grades of 35 percent. On such slopes erosion, if once started, proceeds rapidly. In Europe, slopes with grades of more than 15 percent are considered unsuitable for cropping. In this country the same belief has long been held by foresters and is coming to be entertained by agriculturists and soils experts.

GULLYING ON CLEARED LANDS

In 1929, the Lake States Forest Experiment Station made a field examination to determine the number and extent of the active gullies in Buffalo County, in southwestern Wisconsin, an area of about 50,000 acres containing the river terrace land along many

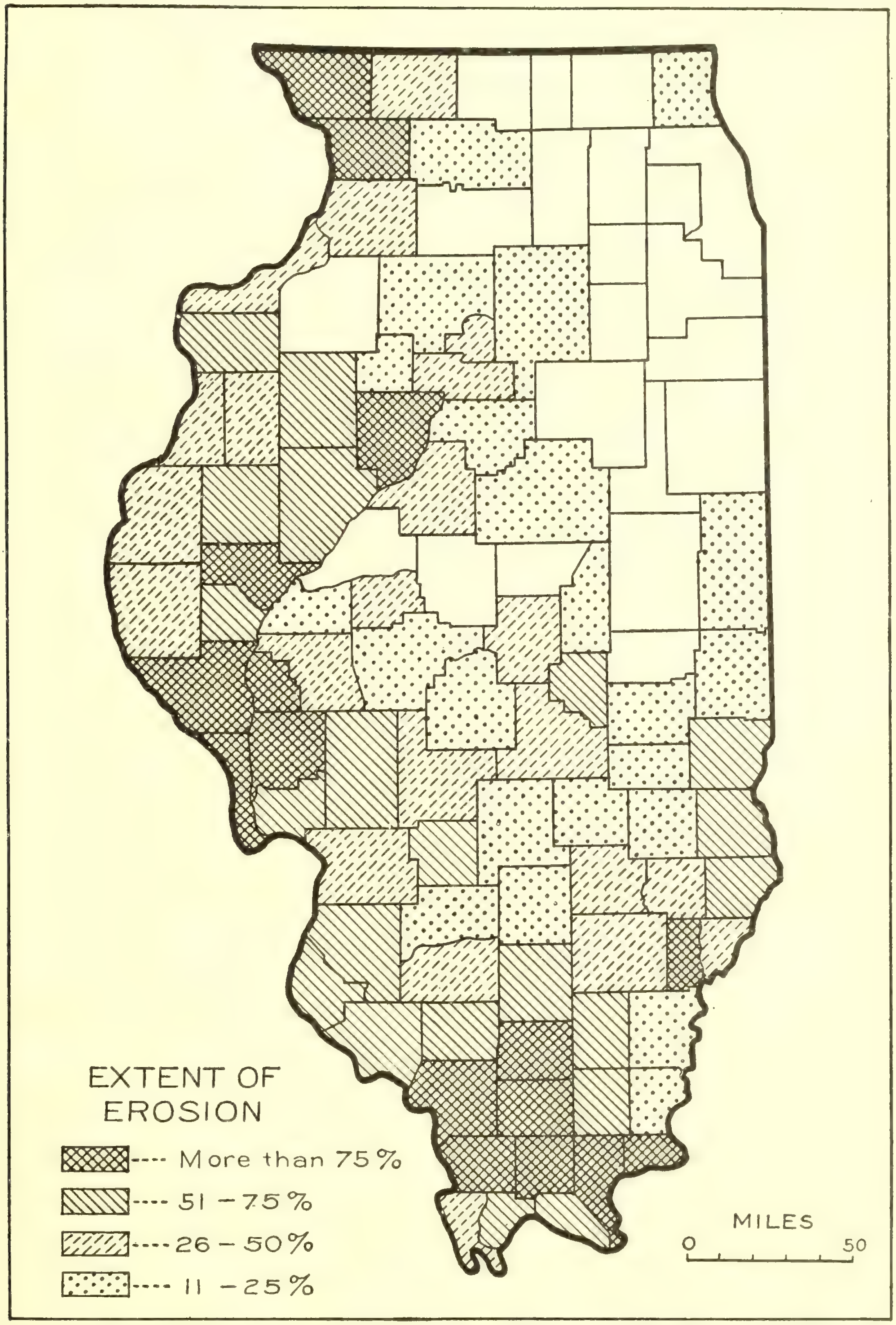

FIGURE 8.—Map of Illinois prepared from data of the Illinois Soil Survey, showing the percentages of county areas affected by erosion of a "serious" and a "destructive" nature combined. (See text for definition of classification.)

miles of the Buffalo River and some such land on tributary streams. From the 170 gullies individually mapped had been removed 3,247,000 cubic yards of soil, or an average per gully of some 20,000 cubic yards. Since on the average these gullies have been active for about 10 years, erosion is removing annually from this small area approximately 300,000 cubic yards of soil, or about 4,000 cubic yards per square mile. With more than 100 square miles in the watershed under cultivation, it is estimated that the average annual silt load of the Buffalo River may total as much as a million cubic yards.

On the adjoining Black River there is no large area where gullying is so prevalent, but some gullies of enormous size have formed in the deep and wide terrace, mostly concentrated in one locality of about 8 square miles. A single one of these gullies has, in about 15 years, dumped directly into the Black River slightly more than a million cubic yards of coarse and fine material. Examination of the drainage revealed 31 active gullies. The volume of soil removed amounted to some 3,850,000 cubic yards, or an average of about 125,000 cubic yards per gully.

Similar conditions exist on loess areas in various places along the upper Mississippi River, as in Calhoun and other counties in southern Illinois.

The fact that so much of the land in the silt loam uplands is being eroded, that the eroded material is dumped so promptly into the Mississippi, and that all run-off from this area is so closely related to the floods in the lower river make this situation one of the really critical national problems. Plans have been proposed for a gigantic waterway system linking the Great Lakes with the Gulf. Because of the excessive erosion now taking place, exceedingly costly dredging would be necessary to construct and to maintain this channel. The silt brought down by streams into the upper portion of the river is creating difficulties for the present 9-foot navigation channel in the upper part of the river.

GULLYING OF BLUFFS

In addition to sheet erosion and the deep gullying of terrace soils a type of erosion independent of the character of cover occurs on the uncultivated bluff area, induced solely by run-off from the cultivated or pastured ground above. Such run-off is often diverted from natural channels to some artificial channel over the bluff. Even though it left the fields without picking up a heavy load of soil, it is capable of causing immense destruction as it passes over the steep rocky slopes, cutting away the loose residual soil mass, undermining and uprooting trees, and eventually, in extreme cases, causing landslides. Coarse detritus deposited by these streams in the valleys often ruins tillable land, and the torrent of water often destroys roads, bridges, and other improvements.

MEASURES NEEDED FOR WATERSHED PROTECTION

To prevent erosion on a private property in the upper Mississippi River Basin is often beyond the power of the owner. Effective control can be brought about only through the initiative and participation of governmental agencies. Great as is the local interest of various public agencies, such as the States and counties in these erosion problems of the upper Mississippi Basin, it is far exceeded by the Federal interest. Nowhere do conditions at the "headwaters of navigable streams" have a more direct and crucial bearing upon Mississippi River problems than in these uplands of Wisconsin, Illinois, Minnesota, Iowa, and Missouri. In few other portions of the United States do erosion conditions approach the seriousness of those of the silt-loam uplands of the Mississippi. The conditions existing on certain eastern mountain areas prior to their purchase for national-forest purposes do not compare with those that now exist on these uplands.

A public acquisition policy is needed. The purpose of such a policy would be first to acquire the more critical areas, plant or otherwise revegetate them, and place them under the form of management that would most quickly develop a full protective cover. Altogether something like 7 million acres in all should be brought into public ownership, including probably 2½ million acres of abandoned farm lands.

Public acquisition would be very difficult. The land involved is held by many small owners, and parts of it are still sufficiently productive that high prices would be asked. The urgency of the situation, however, should prevent these factors from acting as a deterrent. Could sums equal to those that are annually expended for dredging and stream improvement in the upper Mississippi Basin be spent in acquiring eroded land and reconditioning it, the need of continuing this dredging would be largely eliminated.

Planting would be required on at least one third of the eroded abandoned farm lands. This reclamation would be difficult at best; not only has cultivation changed the structure of the topsoil but the subsoil has been exposed over large areas. Investigations are needed to determine what methods of planting should be used.

It would seem desirable to require that on slopes, the grade of which exceeds 10 or 15 percent, a forest cover be restored and maintained.

Special measures of erosion control are needed to reclaim at least 250,000 acres of the most severely gullied land. These would include the use of check dams, soil-saving dams, contouring and ditching, and similar devices. Research is necessary to determine where each of these devices is needed. If erosion proceeds much further, still greater works will be necessary, and over a very much larger area.

Additional fire protection, so badly needed elsewhere, is not urgently required in this basin. Most of the States have very largely attained the objectives set up in the section of this report entitled "Protection Against Fire."

SUMMARY

In the heavily glaciated portion of the upper Mississippi River Basin watershed conditions are not bad. The forest cover, while helpful, is of relatively little consequence in watershed protection because of the absorptive character of the soils, the large areas of swamps, and the relatively level terrain. Only at the very head of the Chippewa River is there any outstanding need for protection forests. Here a forest area of about a million acres should be managed for watershed protection. Because of the very great influence of this basin on Mississippi floods, the Federal interest predominates. Good fire control and simple forestry measures will maintain good watershed conditions.

In the uplands portion of the basin, erosion due to farming and pasturage has affected very large areas and is contributing greatly to land abandonment. The eroded soil is being sluiced into the Mississippi River, constituting an added load to a stream that is notorious for the frequent shifts of its channel and for its sand bars and shoals, and necessitating heavy expenditures for dredging to maintain a navigable channel. Abnormal surface run-off, increased by cultivation, swells the flood crests.

The extensive erosion that is now taking place on the silt uplands calls for definite action. One step would be to prohibit clearing of slopes the grades of which exceed 15 percent and to reforest slopes of this grade that have been used for agriculture. Another would be to reduce pasturage on slopes. Action of this kind would call either for public regulation of forest land or for public ownership of something like 7 million acres of land. The Federal aspects of the problem are far more important than the local aspects.

Possibly a half million acres should be planted in order to insure prompt control of erosion and betterment of conditions. Planting alone, however, will not hold the soil where great gullies have formed; the correction of such gullies will require check dams, soil-saving dams, seeding to grasses and weeds as a temporary aid to forest planting, and correction of stream channels. Such extra work will be required on 250,000 acres of the most severely eroded land.

THE OHIO RIVER BASIN

The Ohio and its tributaries compose one of the most important watersheds in the United States. Although its area of 203,782 square miles is only 16.5 percent of the whole Mississippi River system, the Ohio and lower Mississippi alone can produce a great flood without assistance from the upper Mississippi River or the other tributaries, the latter usually being in moderate flow when the two greater rivers are in flood. [36] The Ohio is the largest eastern tributary of the Mississippi, and contributes on the average 300,000 second-feet to the flow of the greater river. Within its borders about 17,600,000 people or 14.3 percent of our population reside. The region contains fine farm lands, great natural resources, industrial cities, and good markets. The boundaries of the Ohio River Basin in relation to the portions of 14 States which it drains are shown in figure 9.

TOPOGRAPHY

Wide extremes of surface are exhibited by the Ohio River Basin. In the northern and northwestern portions, level to gently rolling agricultural lands predominate on the drainages of the Wabash, Miami, and Scioto Rivers. The elevation varies from about 300 feet in the Wabash bottoms and 800 feet in eastern Illinois to 1,000 to 1,200 feet above sea level in Ohio. South of these level to rolling lands, although the general elevation does not gain, the country becomes more broken and hilly and differences in elevation of 100 to 300 feet in rather short distances are common. Along the Ohio River itself, steep bluffs and highly dissected topography are found from Pittsburgh down to about 50 miles below Louisville, Ky. Within the bluegrass country of Kentucky and the central basin of Tennessee the surface is rolling, but both of these localities are enclosed by rims of higher steep hilly land called the Knobs in Kentucky and the Highland Rim in Tennessee. In the southwestern portion of the basin, on the lower stretches of the Tennessee and Cumberland Rivers, rolling to hilly land is found which in places is comparatively rough.

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[36] Frankenfield, H. C., 1923—The Spring Floods of 1922. Monthly Weather Review Supplement No. 22, p. 5.

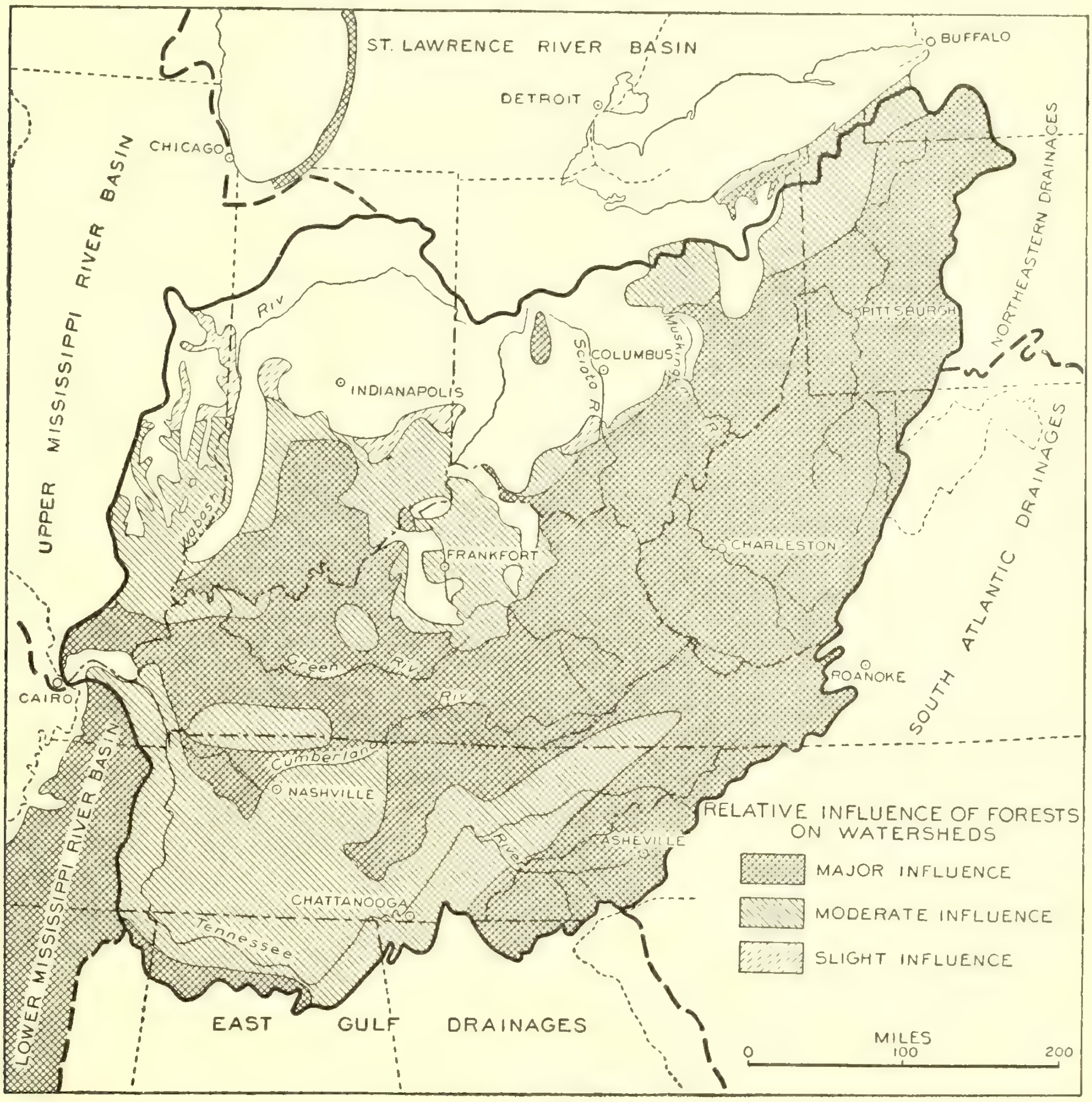
ST. LAWRENCE RIVER BASIN
BUFFALO
DETROIT
CHICAGO
UPPER MISSISSIPPI RIVER BASIN
NORTHEASTERN DRAINAGES
PITTSBURGH
Riv
COLUMBUS
Scioto R
Muskingum
INDIANAPOLIS
Wabash
FRANKFORT
CHARLESTON
SOUTH ATLANTIC DRAINAGES
ROANOKE
Green Riv
Riv
CAIRO
Cumberland
NASHVILLE
LOWER MISSISSIPPI RIVER BASIN
ASHEVILLE
River
CHATTANOOGA
Tennessee
EAST GULF DRAINAGES
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
MILES
0
100
200

FIGURE 9.—Ohio River Basin.

The southeastern and eastern portions of the Ohio Basin are decidedly mountainous in character. They include three distinct provinces, the Blue Ridge, the Appalachian Valley, and the Appalachian Plateau. The Appalachian Valley separates the other two provinces and drains to the southwest as part of the Tennessee River Basin. Within the valley are found long parallel steep-sided mountainous ridges. The Appalachian Plateau to the west includes the Cumberland Plateau of eastern Tennessee and Kentucky and the Allegheny Plateau north of the Kanawha River in West Virginia and Pennsylvania.

Within the Cumberland Plateau, the Cumberland, Kentucky, Big Sandy, and Tennessee Rivers have carved out topography of a highly dissected and mountainous character. Slopes are steep, and ridge tops reach elevations of 4,000 feet. To the northeast the Kanawha, Monongahela, and Allegheny Rivers have dissected the Allegheny Plateau in similar fashion, but the elevations reach only to about 3,200 feet in Pennsylvania. The Blue Ridge in eastern Tennessee and North Carolina attains the highest elevations east of the Rocky Mountains. From a base of about 1,600 feet in the Appalachian Valley, the Ridge rises to high mountainous country containing some 40 peaks over 6,000 feet in elevation the highest of which, Mount Mitchell, is 6,684 feet. Farther north in Virginia, the Blue Ridge reaches an elevation of about 4,000 feet.

SOILS

In the more level northern and northwestern portions of the Ohio River Basin, the soils are of glacial origin. They are derived from glacial flour and drift resulting from the grinding of limestones, shales, and sandstones. For the most part they include loams, silt loams, and loamy clays, but in places rather light sandy soils are found. They have not developed the porosity characteristic of much older soils.

Most of the rest of the basin contains residual soils formed in place by the weathering of underlying rock formations. Exceptions are the alluvial soils along stream bottoms and river benches, and certain areas of loessial soil in western Kentucky, southern Illinois, and adjacent Indiana and Ohio, along the lower portions of the Wabash, Ohio, and Tennessee Rivers. Large areas of weathered clays, loams, and sandy loams in the hilly and Appalachian Plateau provinces have been derived from shales, limestones, and sandstones. In the bluegrass country of Kentucky and the central basin of Tennessee, the soils are derived from limestone. In the Blue Ridge province the soils are derived from granites, gneisses, schists, and other crystalline rocks which upon disintegration yield light-textured soils. The Appalachian Valley contains soils derived in large part from limestone.

PRECIPITATION[37]

The average annual precipitation varies from 35–40 inches on the minor drainages north of the Ohio River to 60–70 inches in the Blue Ridge headwaters of the Tennessee River. Throughout most of the lower hilly portion of the basin in Tennessee, Kentucky, and West Virginia the annual rainfall frequently reaches 45–50 inches. Extremes of recorded precipitation range from 19 inches in Illinois to as high as 120 inches in the Great Smoky Mountains of North Carolina.

A relatively small part of the total precipitation comes as snow. The heaviest average annual snowfall, approximately 80 inches, occurs on the headwaters of the Monongahela and Kanawha Rivers. The lowest snowfall is found in the Tennessee River Basin. The average fall of snow north of the Ohio River is about 25 inches.

As a rule, precipitation is well distributed throughout the year, with heavier monthly averages from December to March or April, and lighter averages during autumn. Exceptionally heavy precipitation has been experienced in many localities in the basin. Sudden downpours of the "cloudburst" type have been recorded frequently on the higher and mountainous portions of the basin. Concentrated heavy rains covering most of the Ohio Basin have been experienced. During the 4 days, March 23–27, 1913, storms brought from 1.4 to 11.1 inches of rain to various portions of this basin.

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[37] Precipitation records cited are taken from Precipitation and Humidity, by J. B. Kincer, U.S. Dept. Agr. Atlas of Amer. Agr. pt. II, A. 1922.

WATERSHED PROBLEMS

FLOODS

Floods are a recurring event for the population living in communities along the major river and on portions of its tributaries. Speaking of the Ohio River in 1913, Horton and Jackson[38] state than in no year since 1873 has the Ohio River failed, at some point along its course, to overflow its banks and flood large areas of adjoining bottom lands, in some years flooding as many as five times. King[39] recites the disasters on the Tennessee and Cumberland River Basins which have come in 1924, 1926, 1927, 1928, and 1929, and shows that the Cumberland River at Nashville has been in flood 73 times since 1874, or an average of more than once every year.

The primary natural cause of floods in this basin is either concentrated and excessive rainfall over a period of a few hours time, as in the floods of March–April 1907, and of 1913, or, in the northern part of the basin, the unfortunate combination of frozen ground followed by snowfall and warm rains, a condition which was responsible, according to Horton and Jackson, for the 1884 flood.

Among man-made causes, Horton and Jackson list the failure of reservoirs, the breaking of levees, and the constricting of stream and river channels by buildings, factories, abutments, grades, and the like. A fundamental man-made cause of floods, not stressed by these writers, but second only in importance to concentrated rainfall, is deforestation and the disturbance or destruction of soil cover.

The damages which can be charged against floods run into very high totals. Horton and Jackson estimate the damage in the Ohio Valley from the 1913 flood as more than $180,000,000. Of this, it is estimated that Dayton, Ohio, received damage amounting to $100,000,000. Four hundred lives were reported lost. In the same deluge, Columbus, Ohio, lost 3 bridges, more than 4,000 dwellings were inundated, 20,000 people homeless, and 100 lives lost. A review of damages as reported in the Monthly Weather Review indicates that the annual losses from floods in the Ohio Valley have averaged about $4,600,000 for the period 1920–32, exclusive of 1925 and 1931. In Tennessee it is estimated that in the years 1926 to 1930 floods brought losses of $20,000,000, or an average of $4,000,000 a year. The flood of March 1929 destroyed more than 100 bridges in the Cumberland Plateau region and middle Tennessee. King estimates conservatively that floods yearly cost Tennessee $1,000,000.

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[38] Horton, A. H., and Jackson, H. J. Flood of March-April 1913—The Ohio Valley. U.S.Geol Survey Water Supply Paper 334, 1913.

[39] King, W. R. Surface waters of Tennessee. Div. of Geol. Dept. of Educ. Bul. 40, 1931.

In the southern Appalachians, Glenn[40] states, the flood loss during 1910 reached some $18,000,000 and in the following year totaled about $9,000,000 more.

The Wabash and White River at flood in January 1930 did $6,862,000 damage (Monthly Weather Review for February 1930). The Southern Appalachian flood of July 1916 did nearly $22,000,000 damage (Ibid., for August 1916).

Records indicate that floods in the Ohio basin are on the increase. Leighton[41] shows by his studies on the three major branches of the Ohio River above Wheeling, W.Va. (the Allegheny, Youghiogheny, and Monongahela), for the period 1885–1907, that "a marked increase in the number of days of floods" is clearly indicated. Table 8 points out the trend in flood increases from 1871 to 1922 in different portions of the watershed of the Ohio Valley. The agreement of data by the United States Weather Bureau for Cincinnati, Ohio, with that for Pittsburgh, Pa., by the flood commissioner, implies that causes of flood increase are similar on the basins of the Muskingum, Kanawha, Scioto, and Big Sandy Rivers to those on the Allegheny and Monongahela Rivers above Pittsburgh. Ashe[42] has indicated an increase in number of days of flood on the Ohio River at Wheeling, W.Va., where the flood stage is 20 feet, from 102 (1838–47) to 220 (1898–1907) and in number of floods from 34 for the early period to 55 for the latter. In the southern part of the drainage on the Cumberland River at Burnside, Ky., he notes a similar increase in the number of floods above the stage of 40 feet (table 8). In the Tennessee River Valley, King anticipates higher flood crests for storms of the same magnitude than those in the past. It is probable that the frequency of floods is increasing here as in the eastern portion of the Ohio basin.

TABLE 8.—*Trend in number of floods, Ohio River Basin, 1871–1922*

Period	Cumberland River	Allegheny and Monongahela Rivers		Ohio River	Tennessee River
	At Burnside, Ky.[1]	At Pittsburgh, Pa.[2]	At Pittsburgh, Pa.[3]	At Cincinnati, Ohio[3]	At Johnsonville, Tenn.[3]
	Number	*Number*	*Number*	*Number*	*Number*
1871–75	-----	2	5	4	-----
1876–80	-----	3			
1881–85	-----	6	11	7	[4] 7
1886–90	-----	8			
1891–95	3	7	10	7	6
1896–1900	8	5			
1901–05	13	11	15	9	3
1906–10	-----	[5] 11			
1911–22	-----	-----	14	12	10
Total	24	53	55	39	26

[1] Data by Ashe, W. W., 1905—In Preliminary Report of the Inland Waterways Commission. 60th Cong., 1st sess. S.Doc. 325, p. 522.
[2] Data from Report of Flood Commission, Pittsburgh, Pa., 1911, p. 46.
[3] Data from The Spring Floods of 1922, by H. C. Frankenfield, U.S.Dept. of Agr. Mo. Wea. Rev. Suppl. 22. 1923.
[4] Includes 1880.
[5] Includes the floods during January 1911.

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[40] Glenn, L. C. 1911—Denudation and Erosion in the Southern Appalachian Region. U.S.Geol.Sur. Prof. Paper 72.

[41] Leighton, M. O. Floods. U.S.Geol. Survey. Water Supply Paper 234. 1909.

[42] Ashe, W. W. Special Relations of Forests to Rivers in the United States. Preliminary Report of the Inland Waterways Com., 60th Cong., 1st sess., Sen. Doc. 325. 1905.

The causes of this increase in flood frequency, insofar as they arise from human activities, are subject to modification and correction. A solution of the flood problem demands a full recognition of all factors concerned, a determination of methods and objectives, and application of those methods.

WATER SUPPLY [43]

Only in years of drought, as 1925 and particularly 1930, do the water problems appear in their true and full importance. Rains are usually so well distributed throughout the growing season that precautions or preparations against exceptional droughts are not usually made. The drought of 1925 was severe, but the great 1930 drought caught many communities quite unprepared for the reduced water supplies on which they had to depend. Both in towns and country the pinch of want of water was severe.

A thorough study of ground waters and wells showed that the water table was declining. Dr. W J McGee of the Bureau of Soils found that, over a period of 22 years, records of 9,507 wells (a great many of which are within the Ohio Valley) revealed a lowering of the water table at a minimum mean rate of 1.315 feet per decade, corresponding to an aggregate of 13.8 feet for the 80 years since settlement began. The experience of communities, which have found it necessary to deepen their wells periodically, fully corroborates this trend and indicates that the water table and deep ground supplies are still shrinking.

Water supplies are drawn from ponds, cisterns, surface wells, deep wells, and from open reservoirs. For many cities, water is drawn directly from rivers. For example, Columbus, Ohio, has two reservoirs to supply the city, both located on the Scioto River, one above the other. Nashville, Tenn., draws its supply from the Cumberland River; Cincinnati, Ohio, has a municipally owned plant with water taken from the Kentucky side of the Ohio River; Pittsburgh, Pa., takes its water from the Allegheny River. Other cities in the Ohio Valley also use river water.

The 1930 drought emphasized the inadequacy and shrinking of water supplies in the Ohio River Basin. Stream flow ceased in many cases and only the larger streams continued to flow. Within the Wabash Valley, water supplies were frequently so very low that Bloomington, Batesville, Bloomfield, and a number of other towns in southern Indiana had periods of shortage of varying length during which residents had to haul or ship water from outside points. In rural districts, water, both for livestock and domestic use, had to be hauled over considerable areas at various times beginning in midsummer of 1930. It was estimated in February 1931, that in some southern Indiana counties a fourth of the farmers were hauling water. Not until March 1931, was the shortage in municipal and domestic water supplies relieved. In the Miami, Scioto, and Muskingum Valleys, conditions were likewise severe. In the Muskingum River Valley the normally dependable springs went dry. Within the valleys of the Tennessee and Cumberland Rivers, water supplies also were severely diminished. Inadequate ground water failed to maintain the springs; too much of the rain has been running off instead of percolating into the soil.

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[43] Data on water supplies in the Ohio River basin, and the effect upon them of recent droughts have been obtained in large part from H. E. Grosbach, U.S.Geol. Survey district engineer, Indianapolis, Ind.; from Roy L. Morton, State sanitary engineer, Nashville, Tenn.; from Effect of the 1930 Drought upon Ohio Public Water Supplies, by F. H. Waring and F. D. Stewart (Ohio State Univ. Eng. Exp. Sta. News, 3 (3), Suppl. 1931); and from Principles of Water Power Development by Dr. W J McGee (Science, N.S. vol. 34 (885)): 813-825. Dec. 15, 1911.

The quality of waters from open reservoirs and rivers, such as communities use during droughts, is far from satisfactory. Because of the open condition of the supply and its temperature, organic life such as algæ increases tremendously. During 1930, operation of municipal water-supply systems was affected by a condition of the water approaching stagnation. Waring and Stewart state that palatability of the supply for eight cities and villages using water from the Ohio River was impaired, in spite of the fact that sufficient water was in the river to supply the pumps and piping systems. They report that the river became a succession of pools created by the Government navigation dams, and the more or less stagnated water developed obnoxious tastes that could not be entirely removed even by purification. Acids and other industrial wastes became sufficiently concentrated to damage plumbing and fixtures in water systems and households.

Problems of water supply are among the most pressing and important facing the people of the Ohio Valley. Not only are sufficient quantities to meet needs at all times essential, but the water must be pure, potable, tasteless, clear, cool, and reasonably soft to be acceptable.

EROSION

A third major watershed problem of the Ohio Valley is that of erosion. The loss of soil and soil fertility is a fundamental reason for the decline of communities and their prosperity. Loss of capacity to produce wealth makes land less capable of bearing taxation to support local government. Aside from the decline of soil fertility arising from overcropping and lack of proper care of the soil, the greatest cause of soil deterioration is the washing away of the invaluable top soil.

The entire area of the Ohio Valley is subject to erosive processes. The northern and northwestern portions have been damaged relatively little because of the generally level surface. Other factors being constant, the severity and rapidity of erosion varies closely with degree of slope and the roughness of the topography. The greatest severity of erosion is consequently found in the hilly to mountainous sections where erodible soils have been cleared unwisely.

On the hilly southern portions of the Wabash Basin, destructive erosion has taken place. Fisher [44] emphasizes the occurrence of thousands of acres of eroded lands in southern Indiana which were formerly quite fertile. These areas have been destroyed by loss of soil.

In the watershed of the Raccoon Creek in Ohio, a study of Vinton County [45] revealed that although there is not much gullying, sheet erosion occurs generally over the county, especially on the steeper cultivated slopes. In the Muskingum River Valley, surveys by Dr. G. W. Conrey, of the Ohio Agricultural Experiment Station, have shown in some localities as high as 24 percent of the area severely damaged by gullying alone. In the basin of the Monongahela River, Glenn found less erosion in 1911 than commonly occurs in the Appalachian Mountains farther south, because of the practice of seeding the slopes to grass. On the Green River drainage certain soils have been found to erode very severely,[46] and great damage has followed the clearing and use of these lands for agriculture. When erosion progresses far enough, abandonment follows. On the mountainous lands of the headwaters of the Kentucky River, tremendous erosion [47] was found to follow clearing slopes for crop production. On the Tennessee River, Dr. C. A. Moores, director of the Tennessee Agricultural Experiment Station, reports that washing is very severe, involving serious losses, which have, indeed, occurred over the whole State.

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[44] Fisher, M. L. The washed lands of Indiana: a preliminary study. Purdue Univ. Agr. Exp. Sta. Cir. 90. 1919.

[45] Sitterly, J. H., Moore, H. R., and Falconer, J. I. Land utilization in a southeastern Ohio county. Ohio Agr. Exp. Sta. Bul. 485. 1931.

Accepting conditions of watershed as continuing in their present state, King concludes that higher flood stages will be developed in the future, owing to the deposits in stream channels and on river flood plains of material eroded from side hills and steep slopes.

Close estimates have not been made of the amount of land in the Ohio Basin which has been and now is badly damaged by erosion. In this connection, Knight [48] states that between 10 and 15 million acres of the 78 million acres in the Appalachian Mountain area have been seriously eroded and approximately 2 million acres have been permanently ruined for farming by gullying. The total area of badly and seriously eroded land is very large—an immensely important factor in the watershed problems of the Ohio River.

POWER

Because of the large proportion of the Nation's population and large industrial activities which lie within its borders or adjacent to it, the development and realization of long-lived sources of electric power are of fundamental importance in the Ohio Valley and constitute a major watershed problem in the solution of which local topographic features are favorable. From average State estimates by the Secretary of Agriculture in 1911, it seems probable that in the neighborhood of 2 million horsepower can be generated.[49]

Present hydroelectric installations comprise over 1,220,000 horsepower. Muscle Shoals on the Tennessee River, costing about $127,000,000, is the largest individual plant. Only a portion of the available power in West Virginia, Kentucky, Tennessee, and North Carolina has been harnessed. District Engineer H. E. Grosbach estimates that Indiana normally produces 150,000–160,000 kilowatt-hours yearly from plants run by water power, part of them being in the northern part of the State, and that Kentucky has installations of hydroelectric plants for 145,000 horsepower.

Rates of streamflow are of primary importance to the power industry. When streams are in flood the output is reduced; when streams are low, insufficient water is available to maintain the output. Both extremes of greater floods and lower streamflow work to the disadvantage and loss of power generation. In the recent drought, according to Grosbach, production of power on the Wabash River in Indiana had an output of 59 percent normal in 1930 and 72 percent in 1931. According to the same authority, at Lock 7 on the Kentucky River the output during 1930 was 58 percent of the 1929 output and for 1931 80 percent of 1929. At the hydroelectric plant of 3,000 horsepower capacity on the Miami River at Hamilton, Ohio, the output for 1930 was cut down, along with other installations in Ohio, to about 65 percent normal.[50]

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[46] Soil Survey of Muhlenberg County, Ky. U.S. Dept. Agr. 1924

[47] Craig, R. B. Forestry in the economic life of Knott County, Ky. Ky. Agr. Exp. Sta. Bul. 326. 1932.

[48] Knight, H. G. Soil conservation a major problem of agricultural readjustment. Proc. of Nat. Con. on Land Util. Government Printing Office. 1932.

[49] Sec. of Agri. 1911. Electric Power Development in the U.S. S.Doc. 316, pt. II. 1911, table 2, p. 14.

Erosion and the burden of debris, as conditions of stream flow, are fundamental in the life of storage reservoirs and their capacity to store water. Although the fact is usually soft pedaled, the erosion, which is taking place is greatly reducing the life and efficiency of storage reservoirs for power-plant uses. Glenn, in the 1911 report already cited, wrote as follows regarding such conditions in the Southern Appalachians:

> From the slopes along these streams a steadily increasing amount of waste is working its way down their channels, filling the dams and destroying their storage capacity; and this loss of storage means a decrease of efficiency that is calculated by the most experienced mill engineers to amount to 30 to 40 percent in plants that have been built especially for storage and a somewhat less marked decrease in other plants, the exact amount depending on the topography of the basin and the regimen of the particular stream on which the plant is located. So universal is this silting of storage basins that a prominent mill engineer of wide experience in his reports on the construction of power plants no longer calculates on power or on anything except the flow of the stream, and he has increased his usual construction estimates by an allowance for increased storm waters that must be taken care of without endangering the dam or plant. Experience has shown that storage basins constructed in this region in recent years are rapidly filled with sand and silt, through which the stream maintains a channel only large enough to carry the ordinary flow.

There can be no denying the fact that conditions of watershed are pertinent to the power producer and consumer alike, because of the costs and life of developments which are involved. In view of the large capital investments, and in view of the permanence of the market for power among the industries and communities of this region, watershed protection is essential in order to effect the longest possible life of the storage capacities of reservoirs, and the greatest efficiency of installations.

NAVIGATION

The fifth major watershed problem of the Ohio River is that of navigation. The Ohio has greatly changed since settlement in its basin really began on an extensive scale. Its French name, "La Belle Rivière," the beautiful river, depicts its early condition. The Jesuit missionaries that visited the region told of its placid waters that flowed as clear as crystal. Audubon writes of watching the fish in the water as he floated down the river on a raft. The records of those who early journeyed to New Orleans on the white pine rafts from the headwaters of the Allegheny tell of the exceptional clearness and purity of the Ohio. Today the Ohio has a different appearance. It is murky and carries a heavy burden of silt. It is defiled with the mining and industrial wastes and sewage of dozens of cities and towns from its head to the Mississippi.

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[50] Lee, Lasley, 1931—The Ohio Stream Flow Survey. Ohio State Univ. Eng. Exp. Sta. News Suppl. to vol. 3, no. 3, pp. 54–57, 1931.

Navigation was far more important in the past than today. Not only the Ohio but many smaller tributaries of the Ohio were formerly navigable, at least for portions of their lengtns. The first steamboat appeared on the Ohio in 1811. By 1840 there were 1,200 of them plying the waters.[51] Thereafter, largely because of the appearance of the railroad, boat travel declined. By raising the water level through a system of Federal locks, sufficient depth (9 feet or more) is now gained to float boats over the major bars and shoals. A series of 49 dams was completed in 1929 at a cost to the public of over $118,000,000. The annual cost of maintenance is $2,000,000.[52] Some 22,337,000 tons of freight were shipped on the Ohio in 1930, half of which was in the vicinity of and just below Pittsburgh, Pa.

Navigation has fallen off on the Tennessee River also. It is at present interrupted by low flow about 60 per cent of the time and by flood and overflow 1 or 2 percent of the time.[53] In order to restore use of the Tennessee River for water transportation, Congress has recently adopted a new project for this river creating a 9-foot navigable depth from the mouth to Knoxville, a distance of 640 miles, and has authorized an expenditure of about $75,000,000 to accomplish this.

Despite the tremendous investment in water transportation, inadequate or little effort has been made to protect the watershed contributing to the flow of the Ohio and its tributaries to establish a more uniform flow, or to eliminate the silt burden dumped in it continuously from eroding lands by unnecessary and abnormal run-off.

CAUSES OF WATERSHED PROBLEMS

The causes of increasing floods, inadequate water supplies, destructive erosion, reduced efficiency of power plants, and hindrances to navigation very largely arise from misdirected human activities. Because these disturbances are man made, they are subject to correction and modification. Deforestation and destruction of surface litter is a primary cause of the extremes of stream flow which the communities in this region now experience. Run-off has been greatly increased in times of rainfall with consequent decrease of stream flow in times of drought. Several practices are responsible for these circumstances.

CLEARING OF NONAGRICULTURAL LAND

The clearing or cultivation of land which erodes badly when cleared is a primary cause of unbalanced stream flow. Many observers have recorded the accelerated run-off and waste of soil which follow the clearing and exposure of mountain lands within this basin. Ashe and Ayres [54] credit land clearing as the most permanently destructive practice used on mountain lands and maintain that much of this land should forever remain in forest, some of the cultivated fields sloping at an angle of 30° to 40°, and some being even too steep for the mountain steer and bull-tongue plow.

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[51] Switzer, J. E. The completed Ohio River Project. Proc. Indiana Acad. Sci. 41: 339–349. 1932.

[52] Annual Report, Chief of Engineers, U.S. Army. 1929 pts. I and II, 1932, pt. I.

[53] Report from Chief of Engineers on Tennessee River and Tributaries, 71st Cong., 2d sess., H.Doc., pt. (1): 328, 38–41.

[54] Ayres, H. B., and Ashe, W. W. The Southern Appalachian Forests. U.S. Geol. Survey. Prof. Paper 37, 1905.

Glenn points out the immediate gullying of cleared slopes which, even though in grass, wash down to the bare rock. Craig in Kentucky, in the bulletin already cited, notes the use of land for corn fields on slopes as steep as 75 percent, where, because of erosion, the maximum limit of arability is 15 years.

Even in lower country severe soil losses take place. In Hopkins County in western Kentucky, a small reservoir and watershed of 2,340 acres were examined[55] for siltage after 20 years' time. Maximum differences in elevation in the watershed amounted to only 206 feet. The steeper slopes were wooded. Of the 930 acres farmed, 350 were in grass. Silting had taken place, however, at the average rate of 3,534.6 cubic yards a year. The cultivated land was rolling and had only 40 feet difference in elevation; yet the burden of silt, almost entirely from the cultivated lands, amounted to 6 cubic yards per acre per year. This is illustrative of the loss that can and does occur from erosion of gentle or rolling arable lands. It does not adequately portray the soil damage being done on rougher and steeper lands.

Glenn notes that in the process of land clearing in the mountains, the soil frequently has been washed away and the area abandoned before the land is completely cleared of the girdled forest. Adjacent areas are then cleared and the process is repeated. Ayres and Ashe, as already cited, estimated that 24 percent of the Appalachian Mountain area has been cleared. The reclearing of abandoned areas has helped to lower the net total cleared average.

Not only does the land soon wash away when slopes are deforested and exposed, but rainfall runs off down the stream courses in excessive quantity instead of percolating into the soil. Leighton, by his studies (already cited) on the three major branches of the Ohio River above Wheeling, W. Va., clearly proved the increase of run-off and the progressive increase in flood occurrences on a drainage area the deforestation of which had been constant and rapid for 30 years. He states without qualification that—

> the increase in flood tendency * * * is due by far the largest measure to the denudation of forest areas.

Run-off varies in different portions of the basin and is increasing in proportion to the deterioration of the surface conditions. Humphreys and Abbot[56] estimated in 1861 that the proportion of run-off to rain in the Ohio basin is 24 percent. Measurements given in the 1911 report of the Pennsylvania Flood Commission show that for the period 1899–1910 mean annual run-off above Pittsburgh varied from 40.0 to 71.7 percent of the rainfall, and that at Wheeling, W.Va., for 1904–8 it was 58.9 percent. On the Allegheny at Aspinwall, Pa., it was 66.4 for the years 1903–7. Recent measurements in Tennessee reported by King indicate that 45 percent of the precipitation usually runs off into streams of that State, and that in the "cloudburst" causing the 1929 flood, measurements indicate that 91.5 to 97.3 percent of the concentrated rainfall was immediately lost as run-off.

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[55] Atkinson, J. B. Watershed of Loch Mary. The Bee, Earlington, Hopkins County, Ky., Mar. 11, 1909.

[56] Humphreys and Abbot, The Physics and Hydrology of the Mississippi River, Philadelphia, 1861; see also Fuller, M. L., Underground waters of eastern United States. U.S. Geological Survey. Water Supply Paper 114, 1905.

Loss of soil porosity, a major reason for the accelerated and at times almost complete run-off from cleared lands, is shown by studies[57] in Ohio. These show that the top inch of forest soils absorbs 51 times as much water per minute as does the top inch of adjacent field soils; that the forest soil at a 3-inch depth absorbs water 14 times as fast as do field soils; and that forest soils at an 8-inch depth absorbs water twice as fast as similar field soils. Studies in Mississippi and Wisconsin on the relative volume of run-off from cleared bare soil and from forested land fully substantiate the evidence of greatly increased run-off following removal of forest growth.

FIRE

Forest fires have greatly deteriorated portions of the Ohio watershed. Uncontrolled fires in the slashings following lumbering, and light burning to encourage the growth of grasses and sprouts, have contributed heavily to the creation of conditions unfavorable to regulated stream flow. Brooks[58] states that the wholesale destruction by fire of the protective softwoods forests and peaty soils began about the time of the Civil War, when an opening was begun by a fire which spread from the camp of Confederate Scouts on the Roaring Plains of Randolph County, W.Va. Prior to 1915 very few records were kept to show the extent of early forest fires in this basin. Prof. C. S. Sargent in volume IX of the tenth census, records the burning of 2,183,393 acres in the States of Indiana, Kentucky, Ohio, Tennessee, and West Virginia during 1880. In 1908, a particularly bad fire year, 3 percent of the estimated standing timber in West Virginia (some 944 million board feet) was destroyed according to the report of the West Virginia Conservation Commission, as quoted by Brooks. Every county in the State was visited by fire, and the total area burned over by the 710 reported fires represented more than 10 percent of the whole surface of the State and 20 percent of its forest area.

The areas of watersheds now damaged by fire are very large. Data compiled by the Forest Service on the areas of land burned over since 1920 are given in table 9 for States lying almost wholly in the Ohio River basin. Inability to subdivide States makes it inadvisable to show areas being damaged by fire for other States. The causes of fire are almost entirely man-made.

TABLE 9.—*Areas of forest burned over, by years and States, Ohio River Basin, 1921–31*

Year	Indiana	Kentucky	Ohio	Tennessee	West Virginia	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
1921	2, 275	32, 940	9, 851	30, 437	11, 900	87, 403
1922	2, 834	104, 735	17, 215	83, 141	159, 182	367, 107
1923	33, 405	287, 421	10, 666	115, 118	189, 916	636, 526
1924	32, 093	367, 998	13, 491	224, 944	32, 406	670, 932
1925	12, 765	69, 377	19, 479	310, 248	61, 681	473, 550
1926	3, 090	41, 040	2, 285	114, 000	50, 763	211, 178
1927	9, 000	48, 910	2, 260	84, 590	18, 030	162, 790
1928	10, 000	184, 850	13, 600	151, 700	121, 210	481, 360
1929	18, 350	154, 150	5, 830	78, 610	41, 170	298, 110
1930	200, 000	755, 720	30, 710	859, 490	353, 400	2, 199, 320
1931	146, 000	718, 450	16, 090	674, 400	136, 530	1, 691, 470

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[57] Auten, J. T. Porosity and Water Absorption of Forest Soils. In press for Journal of Agricultural Research, U.S.Dept.Agr., 1933.

[58] Brooks, A. B. Forestry and Wood Industries. W.Va. Geol. Survey. 5 : 51, 52, 1911.

The greatest damage by fire to the Ohio watershed is the loss of the forest litter, consisting of leaves, needles, twigs, moss, peat, decaying wood, and other vegetative parts. This forest litter acts as a protective soil covering, and is essential in maintaining the porosity of soil and the preservation of channels and minute holes in the topsoil from the pounding action of falling rain. The destruction of litter by fire removes this protection and partially exposes the soil. Furthermore, the heat of fire damages the loose, granular, porous structure of topsoil, by destroying the organic and inorganic colloids which are so important in maintaining this porous flaky condition.

Very hot fires may burn the forest trees themselves, completely killing them, but this is less serious, in terms of watershed control, than is the loss of litter in every type of fire. The hardwoods tend to renew themselves after fire by sprouting, but repeated burning often prevents more than a brush cover, which while undoubtedly helpful in holding the soil is probably much less effective than the high forest in building up the soil and in preserving favorable conditions of water flow. In the spruce forests at high altitudes particularly, fires have been very destructive. Here the soil is shallow, in places scarcely more than deep duff of undecayed litter. Where this has been burned, the soil itself is practically destroyed. Studies by the Appalachian Forest Experiment Station in West Virginia on the Shavers Fork burn of 1924 indicated that from 12 to 18 inches of spruce and hardwood litter and detritus accumulation was destroyed by fire. On such areas vegetation is slow to return.

Efforts to control fire took form first in West Virginia in 1908. In Ohio, organized fire protection began about 1921 for the southern forest zone; for southern Indiana, about 1930. Efforts to effect fire control in Kentucky and Tennessee have been inadequate, and protection on federally controlled areas has begun only as the first units were established. Far better and more adequate fire protection is needed throughout the forested portions of this basin, in addition to the excellent work done heretofore. With more adequate fire protection, watershed conditions in this basin should rapidly improve insofar as fire is concerned.

GRAZING

The influence on stream flow which grazing exerts in the Ohio River watershed consists of the effect which domestic animals have on woods and soils conditions. Confining stock to small areas of forest results in destruction of forest litter from continual and repeated trampling and cutting by sharp hoofs. The porous condition of the forest soil is then quickly destroyed, not only by the loss of forest litter, but by the heavy weight of the animals themselves. By repeated trampling and moving around, the soil is compacted and firmed until it is impervious except to very slow rainfall. Further damage includes the loss of undergrowth and seedlings which the livestock consume and the barking and trampling of tree roots.

The greatest influence of grazing is found in the agricultural regions where large numbers of livestock are raised, and are confined on small areas. Within the rougher, more wooded portions of the basin, grazing is a minor factor; but in the agricultural localities it is a very important one. Later reference will be made to grazing.

LUMBERING

The removal of the forest by logging has been a very disturbing factor in the Ohio River drainage. But the harvesting of virgin timber in itself has not been as disastrous to the conditions of stream flow as have been the elements of repeated fires and the clearing of nonagricultural land, especially in the rougher portions of the basin.

In the smoother portions of the basin, on the Wabash, Miami, and Scioto Rivers and in the Karst, Bluegrass, and Central Basin regions of Kentucky and Tennessee, cutting was originally done to clear land for raising crops. Available records[59] show that the forest area of Ohio declined from almost 14 million acres in 1853 to less than 5 million acres by 1880. Similarly, in Indiana, forests were reduced by 3 million acres in the decade 1870–80.[60] In the rough eastern portions of the basin, clearing occurred later. Leighton, already cited, implies that rapid deforestation was occurring on the Allegheny and Monongahela Basins from 1875 to 1907. In the rough Cumberland and Allegheny Mountains cutting and culling of the forest waited upon but closely followed development of railroads.

Since 1900 lumber companies have been rapidly cutting over the remaining forests in the rougher sections of the Ohio Basin. The peak of lumbering in the Ohio River Basin was reached about 1899–1910, with a cut of some 5 billion feet, and has since fallen to the 1869 level of about 2 billion feet in 1929. There is very close agreement between the advance of lumbering, the period of repeated uncontrolled fires, the increase in run-off, and the increase in number of flood crests, save that the damage done to watersheds has rather increased than otherwise with the decrease in lumbering.

DIVISION OF LAND USE

For purposes of this report, the Ohio Basin is found to classify broadly into (1) the level agricultural land, which, because of soil fertility and ease of cultivation, has the ability, when intelligently handled, to stand up under the demands of agricultural use; (2) the forest land, which because of its rough, steep, and broken surface is unstable and subject to erosion when cleared. Broadly speaking, this division follows the line of glaciation.

North of the Ohio River, the level to gently rolling plain is a result of several advances of the ice sheets. In the balance of the basin the land is in the process of eroding down to a more level surface. In general, the glaciated section is farm land, and the major part of the rest of the basin is too steep or erodible to bear cultivation. Within the unglaciated regions there are such provinces as the Karst, Bluegrass, Appalachian Valley, and Central Basins of Kentucky and Tennessee which are agricultural. In this report they are considered with the farm lands north of the Ohio River.

FARM LANDS

Fire is not a serious problem on farm land because of the separation of remnant woods by the large cultivated areas. Most farm woods are seriously overcut and overgrazed and these are the major destructive agencies. In their present limited extent they can be classified as having slight or at best only moderate influence on watershed problems within the glaciated province, and moderate influence on the agricultural lands to the south and in the Appalachian Valley. (See fig. 9 for relative influence of forests on watersheds.)

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[59] First Annual Report—Ohio State Bureau of Forestry, Columbus, Ohio, 1886.

[60] Pegg, E. C., and Thomas, M. B. The Woodlot for Central Indiana. Proc. Ind. Acad. Sci. 18:419–440, 1910.

Under constant grazing, these woodlots have steadily deteriorated until the forest has become merely open parks, open-air pens, or feed lots. Under such a condition the forest is of little value from a watershed standpoint, and there is reason to anticipate the destruction of the woodlots themselves.

Auten's work, already cited, in the Central States Forest Experiment Station's study of soil conditions in grazed and ungrazed woods in Ohio, showed that for 36 plots, the top 9 inches of soil in the grazed area averaged 15 percent heavier than similar top soil from ungrazed woods. This increase in density is a reflection of the greatly reduced capacity of the grazed soils to absorb water.

In Ohio, the survey of deep-well supplies following the 1930 drought, by Waring and Stewart (already cited in the discussion of "Water Supply"), revealed that, instead of being replenished by fall and winter precipitation, the water level of the deep ground-water supplies was either stationary or slowly receding. Obviously, water is not getting into the soil in adequate quantities. Whether through loss of forest cover and forest soil porosity, or through tiling and open drainage ditches which drain off rainfall immediately, the effect of lowered water table is the same.

The problems of run-off and erosion in the farming section are agricultural problems and as such farm practice is responsible for them. The judicious treatment of farm lands can very largely meet the demands of watershed considerations in so far as they concern farming sections. Owners of valuable farms can, by the best farm practices, maintain their lands in a continuously productive state. Intelligence and concern are essential to careful handling of these lands.

FOREST LANDS

The original forest exerted a very great influence on the streams and rivers which had their source in the high Allegheny and Cumberland Plateaus and the Southern Appalachian Mountains. An estimate of the influence of forests on stream flow in this basin, as shown in figure 9, is given in terms of area in the following tabulation:

	Acres
Total area of Ohio River Basin	130, 420, 480
Total forest area	45, 391, 000
Forest area of great influence	35, 919, 000
Forest area of moderate influence	7, 569, 000
Forest area of slight influence	1, 903, 000

OWNERSHIP OF FOREST LAND

By far the largest portion of forest lands in the Ohio basin is in private ownership. In the aggregate, small owners control a large area of forest, but there are also many large holdings, as coal, gas, and oil corporations, as well as a few lumber companies. This private ownership is unfavorable to conservative handling of these lands.

The need for protection and management of watershed land at the headwaters of the Ohio has been recognized by the Federal purchase of certain lands in this basin. The Allegheny National Forest is on the headwaters of the Allegheny River, a portion of the Monongahela National Forest occurs on headwaters of the river of that name, parts of the Unaka, Cherokee, Nantahala, Pisgah, and Alabama National Forests are on portions of the headwaters of the Tennessee River, and a portion of the Unaka National Forest takes in headwaters of the New River. Because the present extent of these lands (about 2,400 square miles) is too limited to be most effective, the Forest Service plans to add to them. Plans have also been approved by the National Forest Reservation Commission for a national forest purchase unit on the headwaters of the Kentucky River.

Some States in the Ohio basin are also engaged in programs of forest-land acquisition. Reference to the section of this report on "State Accomplishments and Plans" will yield in tabular form the acreages of State forests in Indiana, Ohio, Kentucky, and West Virginia.

A few progressive communities are protecting reservoir sites and watersheds by forests. For example, Akron, Ohio, has 5,000 acres in a municipal forest. Wellston, Ohio, has a 300-acre watershed above its storage reservoir. Denuded lands on this area have been planted. Other Ohio cities having municipal forests include Oberlin and Cincinnati. The Mahoning Valley Sanitary District, which supplies water to Niles, Youngstown, and Girard, possesses 4,500 acres.

MARGINAL FARM LAND

A necessary step in the solution of watershed problems for the Ohio River is the removal of submarginal and marginal land from the status of farm land. Such land is not agricultural at the outset because of many considerations, and continued use aggravates the problems of watershed as well as of agriculture. For example, Sitterley's study (already mentioned) in the southeastern section of Ohio shows a shrinkage in improved lands in farms from 56 percent in 1900 to 26 percent in 1930. The number of farms has decreased 51 percent in 30 years. The population of Vinton County in this region shows a decline of 40 percent. A similar study in another county found a decrease of 20 percent in the acreage of land in farms since 1880 and a decrease of 50 percent in the improved land in farms since 1900. Only 15.7 percent of the total area of the county was in harvested crops in 1929.[61]

It is evident that these areas of land are unable to support an agricultural system, its population, and local government. These studies are illustrative of about 14 counties in this vicinity, in which a million acres of land are lying idle outside of farms and half a million acres within the boundaries of farms. Much of the badly eroded farm land has been abandoned to revert to forest. As high as 50 percent of certain counties in southern Ohio might well be in forest. The use of much marginal land for pasturing seems unlikely. A specialist in crops and soils [62] at Ohio State University states, "Between 55 and 60 percent of the now so-called permanent pastures in Ohio * * * should be returned to forests as the cost of liming and fertilizing makes pasture production prohibitive."

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[61] Sitterley, J. H., Moore, H. R., Falconer, J. I. Land Utilization in Lawrence County, Ohio. Ohio Agr. Expt. Sta. Bul. 514. 1932.

[62] Bailey, M. V., Permanent Pastures. Ohio State Univ. Agr. Ext. Service Bul. 61.

A study of Laurel County, Ky.,[63] by the Division of Land Economics, United States Department of Agriculture, and the University of Kentucky, led to the conclusion that cropping land for corn on steep slopes results in rapid erosion and early abandonment; that the cycle of subsequent reclearing and recultivation leads to decline in soil and economic returns to the point where returns are less than direct costs; that this is the condition on 25 percent of the crop land at the present time; that on an additional 19 percent soil "mining" was necessary to cover costs; and that 4 out of every 10 acres of crop land are losing money.

In his similar study in Knott County, Craig found that all the better agricultural land on these slopes has been made nonarable through erosion.

A recent study in West Virginia [64] found that 85 percent of the locally raised taxes were absorbed by schools and roads, and that "although the maximum rates permitted by law have been levied for most purposes, deficits are common, particularly in the general county and the various school levies. The deficits are becoming more frequent on account of the declining value of agricultural, coal, and timber lands." Another West Virginia investigation [65] pointed out that the prosperity and well-being of farmers is closely related to the soil type and topography of their farms.

It is thus shown that a considerable part of the problem of the agricultural lands is also a problem, and an important one, of the forestry problem on watershed lands. The seriousness of the situation is too great to be ignored, and the area is far too large to be left to take care of itself. The social phases no less than the strictly economic phases require thoughtful consideration. Since conditions of stream flow have been unbalanced by the removal and the deterioration of the forest, they may be improved by reestablishing the forest on denuded lands and by building up the forest where it has deteriorated.

SUMMARY

The problems of watershed are among the most important ones which confront the communities of the Ohio Valley. Floods causing yearly damage of about $4,600,000 and as high as $180,000,000 are on the increase; domestic water supplies are inadequate and too frequently drawn from questionable sources. Erosion is destroying or else robbing the producing capacity of millions of acres of the soils, especially those which have been exposed injudiciously. Hydroelectric power of some 2 million horsepower has immense potentialities, the full realization of which depends on the regulation of stream flow and the elimination of a heavy burden of debris and soil wash. The maintenance of navigation is being heavily subsidized at public cost with inadequate attention to the watershed concerned. Over the last 11 years, about 15,738,000 tons of freight have been shipped annually on the Ohio River alone, whereas in 1930 all shipments by water were some 22,337,000 tons.

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[63] Clayton, C. F., and Nicholls, W. D., Land Utilization in Laurel County, Ky. U.S.Dept.Agr. Tech. Bul. 289. 1932.

[64] Peck, M., Frank, B., and Eke, P. A., Economic Utilization of Marginal Lands in Nicholas and Webster Counties, W.Va. U.S.Dept.Agr.Tech.Bul. 303. 1932.

[65] Phillips, S. W. 1925—Soil Survey of Nicholas County, West Virginia, U.S.Dept.Agr.Bur. Soils Field Operations. 1920. Rpt. 22. 39-59 illus.

The irregularity of stream flow is directly increased by man-made causes. The increase in run-off and period of low stream flow has been caused by deforestation, in clearing large areas of nonagricultural land, by uncontrolled forest fires, by grazing, and by unregulated cutting with no care for the future. Since 1921 over 660,000 acres have been burned over annually. The forests of this basin have been so depleted that production of lumber has declined from 5 billion feet in 1899–1910 to 2 billion feet in 1929.

In the agricultural sections of the basin, the solution of these problems is to be found in using better agricultural practices and in the elimination of harmful grazing from wood lots. Fire is a small factor. On the forest lands, the permanent regulation of streams demands a rebuilding and improvement of the forest through the elimination of fire, harmful grazing, and unregulated lumbering. The extension of organized fire protection to the entire area needing protection with higher standards and better organization is essential. The return of forests to 4 million acres of land of nonagricultural character must be accomplished in part by planting. Because private initiative is incapable or unwilling to attempt these measures, a vigorous policy of public acquisition of cut-over, abandoned, and marginal land amounting to 28.6 million acres is essential. Of this, probably 6 million acres will be in abandoned farms, and 22.6 million acres will be forest land. Most of this latter area is located in the higher and rougher portions of the drainage and including the mountainous sections at the headwaters. Only through good protection and management of these forests can favorable conditions of water flow be restored. Part of this public ownership must be Federal, because of differences between States in wealth and ability to meet the task. An enlarged program of public education through extension under active leadership and with full participation by all agencies is highly desirable.

Ashe writes (op. cit.):

> The work of the engineer to protect the large river becomes useless unless it is protected by the forest. In the Appalachians * * * and indeed wherever forest influences are high, the river engineer and the forester must work hand in hand.

MISSOURI RIVER BASIN

The total drainage area of the Missouri River is about 525,000 square miles, including all or parts of 10 States and some 13,000 square miles in Canada (fig. 10). Of the 28,642,000 acres of forest, some 20,515,000 acres is classed as having a major influence and 6,769,000 acres a moderate influence upon watershed conditions. The remainder is rated as exerting comparatively slight influence.

Topographically the Missouri Basin is most varied. About one twelfth of the surface is mountainous, one sixth plains, and the remainder rolling. Because conditions vary so widely, the drainage is considered as in two parts, the upper Missouri, or semi-arid section to the west, and the lower Missouri, or humid sections to the east. The dividing line between these approximates the one hundredth meridian.

UPPER MISSOURI RIVER

The headwaters of the upper Missouri River lie in the Rocky Mountains, a region of rugged topography. The mountain area consists principally of a strip of high mountains, varying in width from

10 to 100 miles, along the western edge of the basin. Along the Continental Divide the mountains are broken and exceedingly steep. Crests and peaks, and in some localities high rolling plateaus, at elevations of 9,000 to 11,000 feet or more, rise above narrow valleys of 5,000 to 6,000 feet elevation. Within the Plains region, many miles

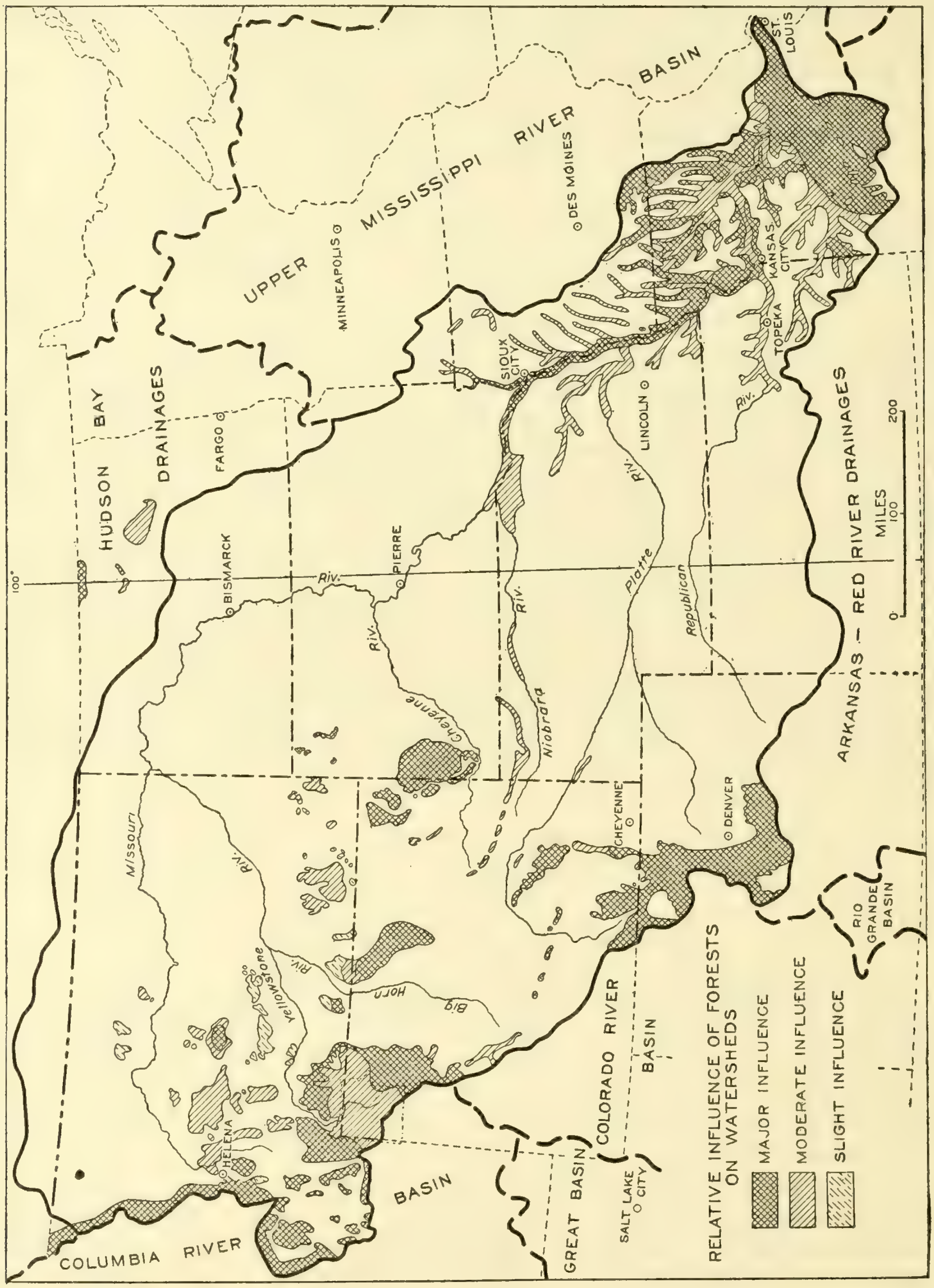
UPPER MISSISSIPPI RIVER BASIN
HUDSON BAY DRAINAGES
ARKANSAS - RED RIVER DRAINAGES
COLORADO RIVER BASIN
GREAT BASIN
COLUMBIA RIVER BASIN
RIO GRANDE BASIN
ST. LOUIS
DES MOINES
MINNEAPOLIS
KANSAS CITY
TOPEKA
SIOUX CITY
LINCOLN
FARGO
BISMARCK
PIERRE
CHEYENNE
DENVER
HELENA
SALT LAKE CITY
100°
Riv.
Platte Riv.
Republican Riv.
Niobrara Riv.
Cheyenne Riv.
Missouri Riv.
Yellowstone Riv.
Big Horn Riv.
MILES
0
100
200
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE

FIGURE 10.—Missouri River Basin and Hudson Bay drainages.

from the Rockies proper, are a number of forested outposts, of which the Black Hills of South Dakota are an example. In portions of the plains are scattered areas of Badlands and of sand hills.

The soils are usually loams varying from gravelly phases in the mountains to heavy clay loams elsewhere.

The precipitation varies from 10 or 12 inches in the semiarid plains of the Big Horn and Milk River Valleys to 50 inches or more in the mountains. On the average, the precipitation in the forested regions probably reaches 30 inches. Most of this comes in the form of winter snows. Wide variations in the precipitation occur from year to year and from season to season, variations of 50 percent of the normal being not uncommon.

The thaws are mainly responsible for local floods. Very appreciable differences in run-off occur from year to year, due as much to variations in rate of thawing as to the depth of the snow. As indicated in the introductory statement to this section, the rate of snow melt is affected by the condition and character of the cover, and hence the spring flood flows.

The floods in this upper basin usually have little relation to those in the Mississippi, since by the time the high water reaches the Mississippi, the main floods of that river have already passed on to the sea. They are important locally, however, primarily because of their effect on sustained stream flow. Excessive spring floods affect adversely the summer flow. The agriculture of a very large part of the upper plains region is dependent upon stream flow from the forested areas. In some years, practically all the summer flow is taken for agricultural use. The forested area provides all or practically all the water used by such cities as Denver, Cheyenne, and Rapid City. Any condition that adversely affects sustained stream flow from this area, therefore, reacts to the detriment of regional welfare and prosperity.

Ordinarily the streams in the high mountain area are clear, fed by thousands of forest springs and flowing through numerous lakes. They become muddy or silt-laden only during the period of heavy run-off. Streams rising in the more impoverished soils of the woodland areas are usually not clear, except those coming from high plateaus.

FOREST COVER

The forest belt stretches along the mountain slopes at the western edge of the basin, and takes in the mountain outposts. Although the forest belt includes about 6½ percent of the area of the upper basin, about a third of it is nonforested lands—largely range lands, such as meadows, parks, and grassland plateaus.

The higher elevations are taken by spruce forests, usually dense and maintaining a heavy litter cover. On steep slopes, the forest may be open, but where soil exists, minor vegetation covers the ground.

The lodgepole pine forest is usually fairly dense. Where the lodgepole gives way to ponderosa pine, the forest usually becomes more open.

Ponderosa pine is the principal species of the mountain outposts and sand hills. Owing to the lower precipitation of the plains region, the trees are often of low stature and the forest open but a good ground cover is found where grazing, fire, and cutting have not been too heavy.

The brushy or woodland forest seldom forms a complete cover, reflecting the semiarid conditions under which it has developed.

PRESENT CONDITION OF THE FOREST

For the most part, the forest cover of today is relatively little different from that which existed prior to the advent of the white man.

Early uncontrolled fires did much damage, especially in portions of Wyoming and Colorado. In the pine regions, restocking has taken place. In the spruce type, the devastation caused by some of the early fires has been so complete that after 50 or more years a forest cover is still lacking on many of the burned areas.

Overgrazing probably has caused greater change in the cover conditions of the upper Missouri than any other factor. Large herds, especially in the woodland areas, have so depleted the forest ranges that only a scanty ground cover is found where formerly a more or less complete carpet occurred. Overgrazing still continues in many places.

Timber cutting, particularly about mining and agricultural settlements, has often been most severe in those places where conditions were least favorable for regrowth. As a result, the forest cover on some areas has been badly depleted.

In a few localities where smelters have operated, such as at Butte, Mont., the cover on nearby slopes has largely been destroyed by fumes. In such places the top soil has washed away, leaving an erosion pavement of rock fragments on the surface.

OWNERSHIP OF FOREST LANDS

Private forest lands play a very small part in the water or soil conditions of the upper Missouri Basin. They are mostly in small units, scattered throughout the forested region, more of them in the Badlands than elsewhere. Intermingled with the national forest lands, as many of them are, they receive protection from fire. Few are so accessibly located as to be merchantable and consequently their condition is for the most part about the same as that of the national forests. Where cutting has taken place it usually is too heavy, and where grazed, overgrazing is common. Those in the Badlands have suffered particularly from overgrazing. There is a small area of State or other local public lands in the upper basin. Much of this area is in need of better care. The much larger area of public lands is in Federal ownership or control. These are included in the national forests, nation parks, Indian lands, and public domain.

NATIONAL FORESTS

Of the public lands, the national forests are the most important because of the area of approximately 9 million acres involved, and because of their location at the very headwaters of the river. All forms of use, such as cutting and grazing, are so handled that the watershed cover is maintained in an effective condition. On some of the national forests, where serious overgrazing took place before the areas were put under administration, watershed conditions are not yet entirely satisfactory, but the cover is gradually improving under regulated use.

Fire is not a serious factor. In occasional bad fire years control is difficult, but with the extension of transportation improvement and with more and better equipment there is much less danger of disaster than formerly.

On the whole, the watershed conditions on the national forests are satisfactory and are steadily becoming better.

NATIONAL PARKS

Some 300,000 acres of national park areas located in this basin—the Rocky Mountain, the Yellowstone, and the Glacier—are involved. Under the park policy of excluding commercial use, watershed conditions are being maintained. Cover conditions, which even before the establishment of the parks were not seriously disturbed, are improving.

INDIAN LANDS

There is something over a million acres of forest lands in Indian reservations in this drainage. These are subjected to cutting and to grazing. Past missuse on some of these lands has caused deterioration of the cover. The stands have been cut too heavily, fires have been common, and some overgrazing has taken place. In recent years there has been considerable improvement in the cover due to better fire control and to cutting restrictions. More recently, efforts have been made to institute a type of range management similar to that in effect on the national forests. Although this management has not been in effect long enough to bring about marked changes in depleted ranges, it is to be expected as time passes that watershed conditions will gradually improve.

PUBLIC DOMAIN

Federal lands in the unreserved public domain are in less fortunate circumstances because they are not given as much care and attention as is accorded other public lands. Many of these are in small tracts so scattered that management is difficult. Efforts at fire control and range and forest management on the unreserved public domain have been made, but in the absence of an organization whose specific duty it is to cope with the problem, the situation is not satisfactory. On the whole, much of the cover, particularly the minor vegetation, has been seriously depleted with attendant increased surface run-off and erosion. This is particularly marked in the Badlands.

BADLANDS

"Badlands" is the name given to rough lands in the plains region, mostly in Montana and in the Dakotas. Something over 10 million acres are involved. Although not covered with a commercial forest, most of the Badlands support a brush and low woodland cover that, if adequately maintained, would probably be highly effective in watershed protection. Some support only a sparse vegetation of brush, and some only grass or other minor vegetation. Woodland is characteristic of the north-facing slopes, and grass of those to the south.

Many of the Badlands soils are silty loams which, lacking a binding material, virtually melt in the rain. Although much of the eroded material is so fine as to be carried to the Gulf, a part of it is deposited in the lower part of the Missouri and Mississippi Rivers. Because of the area involved, the extent of the erosion, and the ease with which erosion takes place, this situation is the most critical one in the upper Missouri, and calls for early remedial action. Of the 413 million cubic yards of soil estimated by the War Department as the amount annually carried by the Missouri River into the Mississippi, probably more than half comes from this section.

Most of the Badlands area is grazed and much of it too heavily grazed for the cover to maintain itself. Where grazing is heavy, erosion is greatly accelerated. Even under light grazing use, many of the steep, unstable clay slopes erode excessively. The soils involved, the paucity of precipitation, the alkaline character of the soil, and the character of cover make good management imperative in the interests of watershed protection. Even with good management, it is doubtful whether erosion can be wholly prevented by vegetation alone. Probably some special measures of erosion control will be necessary. The fact that a very large part of this area is public domain serves to emphasize the fact that public ownership alone is not sufficient to insure good watershed conditions.

LOWER MISSOURI RIVER

GENERAL DESCRIPTION

The more humid part of the Missouri River drainage is essentially a prairie region well suited to agriculture. About 4 million acres of commercial forest land is included in this region. This forest is in the form of stringers which follow the streams far into the prairie region, of scattered woodlands in farming communities, and of more extensive forest areas on the rougher lands. A scrubby woodland type of about a million acres is found towards the western extension of the forest in southwestern Missouri and eastern Kansas and Nebraska. The topography is level to gently rolling. Rough lands occur only in the Ozark region of southern Missouri. In northern Missouri and southern Iowa the terrain is more rolling than on the west side of the river.

The precipitation varies from 20 inches in the plains section to 45 inches in southern Missouri. Most of its comes as rain and the greater proportion in the spring and late summer. During the flood years of 1915, 1922, and 1927, spring storms brought between 20 and 30 inches of rain to the Ozark region and the resulting local floods were a material factor in the flood stages of the lower Mississippi. Torrential rains frequently occur. The Weather Bureau reports a rainfall of 6.61 inches in 24 hours at Columbia, Mo., and a fall of 3 inches in 30 minutes at Fayette. Such rains are unusual, but numerous rains have occurred in which more than 2 inches has fallen in 24 hours. Heavy rains result in a high run off particularly from deforested or burned land.

The Ozark streams contribute markedly to the floods of the Mississippi River. Records of the Mississippi River Flood Commission show that of the Mississippi River flow of 1,850,000 second-feet at Cairo on February 6, 1915, the Missouri River contributed about 200,000 second-feet, or 11 percent, of which 150,000 second-feet or about 8 percent of the Mississippi flow at Cairo came from the Osage River, which drains southwestern Missouri. On April 24, 1922, the Missouri River contributed 460,000 second-feet of a total of 1,550,000 second-feet; of this the Osage accounted for 30 percent, or 9 percent of the flow past Cairo. On April 20, 1927, when the highest flood peak of the year at Cairo occurred, the Missouri contributed 20 percent and the Osage 6 percent of the flow of the Mississippi.

The streams of this area also contribute heavily to the silt load of the river. Thus, on the basis of data from the University of Missouri, the Grand River, which drains part of southern Iowa and northern Missouri, furnishes to the Missouri River some 8½ million tons of soil annually. This is about 5 percent of its silt load. The Grand River drainage is but 1.2 percent of the Missouri River Basin. Because of the large contribution of the lower Missouri region to the floods and silt burden of the Mississippi, most of the forest area is classed as having a major influence upon watershed conditions.

FOREST

Most of the forest area is in southern Missouri, of which about 90 percent is privately owned, largely in the hands of farmers. The present condition of the forest, therefore, is largely the result of the use which the farm owner has made of the woods. Only in the more inaccessible areas are there large ownerships.

The forests are chiefly oak, though scattered pine is found in the higher elevations and sandier soils. Timber cutting is typically a culling in which the best trees are taken. Fires usually follow, often purposely set to freshen the grass and to obtain more sprout growth for the cattle. Where fires have occurred repeatedly, they have prevented the extension of pine and caused the development of a low coppice forest. This has been further deteriorated through heavy grazing. Brushy, open, and understocked stands occupy about one fourth of the forest area.

At present there is no organized protection for the forest lands of Missouri. Fire control, where it exists, is strictly a local or private matter. Elsewhere, there is general indifference to protection needs. The result is repeated fires, which render impossible the maintenance of a good litter cover or the development of good watershed conditions.

As described in the introductory statement, studies in oak stands in eastern Oklahoma under conditions which greatly resemble the Ozarks show that surface fires markedly increase surface run-off and erosion. Wisconsin investigations have shown that open and heavily pastured forests do not hold back surface run-off much, if any better, than open land and that grass land is responsible for a high percentage of run-off. Undoubtedly some of the very large contributions this area makes to the floods in the lower Mississippi are due to the recurrent fires and heavy grazing.

In the Ozark region, most of the agricultural development has been on the broad ridges and in the bottoms. The 1930 census data show an increase in the area of crop land in a number of Ozark counties. The new areas are largely on the hillsides where continued agricultural use is doubtful because such lands erode rapidly. It is decidedly questionable whether the public should permit land clearing of hill lands in view of the fact that the resulting erosion is so quickly poured into the Mississippi River. More and more agriculturists and soil specialists are coming to believe that hill lands with slopes greater than about 15 percent should not be cleared.

The question of how these practices—use of fire, heavy cutting, pasturage of restocking and steep lands, and the clearing of hill lands for cultivation—can be controlled is an open one. Certainly some positive steps appear desirable. If public restrictions upon private use are not in order, then public ownership is the only alternative.

The heavy contribution the Ozark region makes to the Mississippi floods indicates that a part at least of the Ozark area should be in public rather than in private hands. The situation is more largely one of Federal than of local interest, and the values at stake are too high to permit continued malpractice to threaten extensive public works and the safety of a large population. About 150,000 acres of abandoned farms and denuded lands need reforestation. Special control measures are necessary on about 50,000 acres.

ABANDONED AGRICULTURAL LANDS IN THE UPLAND LOAMS

The agricultural lands of the upland silt loams have reached a critical stage. Clean cultivation, largely for corn, has resulted in erosion so serious as to make a large area of formerly prairie land of doubtful agricultural value. Much of this area is drained by the Grand River. According to H. H. Bennett of the Bureau of Chemistry and Soils:

> Under continuous cropping to corn the rich top soil (Shelby silt loam of northern Missouri) has been swept away from innumerable areas by erosion, down to a yellow clay subsoil, within a period of about 50 to 60 years on 4 percent slopes, and in about 10 to 20 years on 8 percent slopes. The exposed stiff, yellow clay produces little grass of any value and only about 20 bushels of corn per acre (no corn in dry years) as against more than 50 bushels for the best years on the less severely washed soil. The vegetative changes resulting from erosion on this extensive prairie soil have been most violent, a change from almost exclusive stands of bluegrass, in density of 100 percent ground cover, to scattering weeds and dwarfed grasses of very low grazing value.

At the Bethany (Mo.) Soil Erosion Station, the water loss from an 8 percent slope in corn during 1931 was 30 percent of the total precipitation and the soil loss 84 tons per acre. The corresponding losses from a similar area planted to alfalfa were 0.36 percent of the precipitation and 2 tons of soil per acre. Since forest has been shown by the investigations of the Lake States Station to be more effective than grass or hay cover crops in controlling run-off and erosion, it can be readily realized that forestation on at least some of these badly eroding lands would help to control flood flows and erosion. As forests originally existed on about 40 percent of the abandoned farm land area in southern Iowa and northern Missouri, it is not, therefore, a question so much of putting forest where it has not previously grown, as in restoring it. In 1919 the Iowa Agricultural Experiment Station said:

> Much of the rolling and rough land in southern Iowa that is subject to erosion, especially that near the rivers, was originally in timber and should probably be reforested or seeded down to grass. If this were done little erosion would ever occur.[66]

Recent data from the University of Missouri indicate that 6 million acres of agricultural lands in Missouri are seriously eroding, with gullies 6 to 10 feet deep not uncommon. Dr. M. F. Miller and Dr. C. Hammer of the university estimate that some 2,250,000 acres of these eroding lands need forest planting. Based on an incomplete survey of the whole State, the Iowa State Soil Survey now in progress is revealing that between 2 and 3 million acres of eroding land in Iowa should be permanently taken out of cultivation and planted to trees. The Nebraska Agricultural Experiment Station estimates that more than 8 percent of the farm land in eastern Nebraska is seriously eroded.

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[66] Eastman, E. E., and Glass, J. S. Soil Erosion in Iowa. Iowa Agric. Exp. Sta. Bull. 183, 1919.

Altogether there are about 10 million acres of once fine agricultural land in the lower Missouri drainage which now are of doubtful agricultural value. Because of their relationship to the flood problem of the Mississippi, they are of national significance. Early action should be taken to place this land under some form of management that will prevent further erosion and greater flood losses. For some of the abandoned land that is at least of doubtful value for agriculture, forestry offers a solution. On these lands, it should be possible within a few years to control surface run-off and erosion through planting and other forestry practices.

Conditions are now so serious that it seems scarcely possible for private initiative to correct them. Public ownership of a large area appears to be the only real solution.

GENERAL CONSIDERATIONS

It has been pointed out that where forest lands in the upper Missouri Basin are given management, satisfactory conditions of stream flow obtain, and that on most lands not administered or managed, watershed conditions are not satisfactory. Public lands under close supervision are in the best shape, and some private lands in the worst. The unreserved public domain approaches very closely the worst of the private lands. This is especially marked in the Badlands where grazing is principally at fault. Here in addition to range management, forest planting, reseeding, and the use of erosion control devices are needed to prevent further soil and water losses. Investigations are particularly essential to determine how far these need to be applied and their proper place.

In the lower Missouri, conditions on the commercial forest lands are very unsatisfactory, especially in view of the far-reaching effect of the run-off from the Ozark highlands. Fires are widespread and there is no organized protection against them. Cutting is done without regard to the watershed conditions. Overgrazing in pastures hastens run-off and increases the flood troubles of the Mississippi. Land clearing on steep slopes has gone too far. Private ownership has given little thought to stream-flow conditions. Whether private enterprise will take any specific action is doubtful. Public acquisition appears necessary on about 7.6 million acres. In this area, the National Government is primarily concerned because of the contribution this area makes to the Mississippi River floods.

On the agricultural silt loam uplands within the prairie region, erosion has reached a stage where land is rapidly going out of agriculture. About 10 million acres of these lands are so eroded and impoverished as to be of doubtful agricultural value. Some of them could support a forest of a kind if planted. Public ownership of a large part of these lands is apparently necessary, but the question of ownership as well as that of future use is one that cannot be determined in the light of present knowledge. If erosion is to be controlled and better conditions of stream flow developed, some combination of forestry with other use is necessary. Thorough investigations of conditions and of the measure needed to restore watershed conditions are necessary.

ARKANSAS AND RED RIVER DRAINAGES

The Arkansas River heads in the Rocky Mountains of southern Colorado and northern New Mexico, and after flowing through the plains passes through the mountains in Arkansas to reach the Mississippi. The Red River rises in the foothills of the Rockies in west Texas, flows through the Red Plains, skirts the southern edge of the mountains in Arkansas, and empties into the Mississippi River in central Louisiana. The region drained by these rivers is shown in figure 6, which indicates also the location of the forests in these drainages and their relative influence upon watershed conditions. Of the total forest area of 52,220,000 acres 34,560,000 acres, or 66 percent, is classed as having a major influence upon watershed conditions, 15,525,000 acres, or 30 percent, as having a moderate influence, and only 2,135,000 acres, or 4 percent, as having little or no influence.

FLOODS AND EROSION

The Arkansas and Red River drainages contribute proportionally more to the floods of the Mississippi River than any other section of the great Mississippi Basin. The greater part of this contribution has its source in the Ouachita-Ozark Mountain area of southern Missouri, Arkansas, and eastern Oklahoma; records of the Mississippi River Commission show that at the times of the great flood disasters of 1915, 1922, and 1927, and at other times, this mountain area, although constituting only about 5 percent of the total area of this Mississippi River Basin, has contributed as much as 40 percent of the flood waters in the delta region of the Mississippi. The records show also that the Ouachita-Ozark section contributed more than 50 per cent of the peak flow on May 1, 1927, and nearly 25 percent of the peak on May 7, 1927.

The White River, a tributary of the Arkansas River that drains northern Arkansas, contributes heavily to these flows. W. W. Ashe, using data of the Chief of Engineers, United States Army, has shown that the drainage of the White River, although it contains only 2 percent of the total Mississippi Basin, contributed 7.3 percent of the flood waters of the lower Mississippi in the period 1911–27, inclusive. He pointed out that the western portion of the Arkansas River drainage, although a much larger area, contributed less than 2 percent of the same flood waters. The White River, as its name implies, originally ran clear. For the year 1927 its silt burden was estimated by Ashe at nearly 3 million tons, or 105 tons per square mile of drainage area, or 11 percent of the total silt load of the Arkansas.

Ashe estimated the total annual silt load carried by the Arkansas at some 26 million tons. Of this, he estimated only 5 million tons came from the Ouachita Province. A large part of this silt load reaches the Gulf; the heavier and coarser material, however, is deposited in slack water at or near the mouth of the Arkansas and is the chief cause of shifts of the stream banks and of the channel at that point which sometimes have serious consequences in time of flood.

The western part of the Arkansas and Red River drainages is characterized by different stream-flow conditions. Floods are much more rare, and where the Arkansas passes out of the Rockies it usually runs clear. The water problem is one of getting sufficient supplies for irrigation; in a considerable portion of southeastern Colorado and northeastern New Mexico agriculture is dependent upon the flow of mountain streams included in these drainages.

In the central or plains portion of the two drainages floods, water supply, and erosion are all important locally. On the upper part of the Cimarron, a tributary of the Arkansas, the Folsom flood of August 1908 cost many lives and almost totally destroyed the town of Folsom. The State of New Mexico plans to construct three flood-control reservoirs on the head of the Cimarron. To impound about 50,000 acre-feet of water the Oklahoma State Commission of Drainage, Irrigation, and Reclamation has developed plans for 18 flood-control reservoirs in the Cimarron Basin which would have a storage capacity of nearly 1,750,000 acre-feet. The value of these reservoirs would depend largely upon controlling soil erosion and thus preventing sedimentation.

TOPOGRAPHY

Topographically, the Arkansas and Red River drainages are most varied. In the extreme west the Rockies rise to elevations of 14,000 feet, some of the high peaks bearing perpetual snow. Steep slopes and rugged topography prevail in the Rockies. The foothills, below 6,000 feet, are much less broken. Largely because of the roughness of the topography, most of the Rocky Mountain forest area is classed as having a major watershed-protective influence.

The plains region, which constitutes something like 60 percent of the two drainages, is largely a gently rolling area. The "Breaks" are a badly dissected area in the Red Plains of western Oklahoma and northeastern Texas where the streams flow in cuts from 300 to 500 feet below the plains level. This area is characterized by steep escarpments or sometimes almost perpendicular cliffs with steps and terraces down to the streams.

Western Arkansas, eastern Oklahoma, southeastern Kansas, and southern Missouri are composed largely of highlands. Elevations in excess of 2,600 feet exist, although most of the hills are below 2,200 feet. The topography is much broken and slopes are steep; partly for this reason, the forests that occur on these highlands are classed principally as protection forests.

Rolling hills, seldom exceeding 500 feet in elevation, occur in southern Arkansas, eastern Texas, and northern Louisiana.

The alluvial valley at the eastern end of these drainages is practically a level floor less than 200 feet above sea level. Flood waters drain from this valley slowly. The bottomland forests are classed as having little or no watershed protective influence.

PRECIPITATION

Great differences exist between different parts of the Arkansas and Red River drainages as to quantity, intensity, and seasonal distribution of rainfall. In the east the average annual precipitation is around 50 inches, but annual precipitation as high as 109 inches has been recorded. Toward the west the precipitation gradually becomes less, reaching a minimum of about 12 inches in the plains. It rises again to 30 or 35 inches in the Rocky Mountains, where a considerable portion of the precipitation occurs as snow.

In the lower part of the drainages about one third of the precipitation occurs during the spring months. In Arkansas 24-hour rainfall is recorded to have totaled as high as 8½ inches and exceeds 5 inches not uncommonly. In the spring flood periods of 1882, 1912, 1913, 1922, and 1927, the rainfall in the Ouachita-Ozark region ranged from 15 inches to 35 inches. In the plains region the precipitation during the winter and spring months is only about one third of the annual total. Most of the rains come in midsummer, with marked irregularity from season to season. At Twin Buttes, Colo., 8½ inches, or half the total annual precipitation, has been known to fall in 1 month.

In the foothills and lower slopes of the Rocky Mountains, cloudbursts are not uncommon. This type of rainfall has been responsible for much of the flood damage in eastern Colorado. The Pueblo flood of June 1921 which caused damage in excess of $25,000,000 and the loss of 120 lives, was caused by a rain of more than 7 inches of which half fell in 1 day.

In the Rocky Mountains proper, a great part of the total precipitation is snow. The melting of this snow causes high water in the streams but no particularly damaging floods.

SOILS

In this region Ashe recognized four broad types of soil in addition to the alluvial soils. He described these, and estimated the proportion of the drainage areas on which they occurred, as follows:

1. Silts, very fine sands, and fine sandy loam, which are deficient in cohesion and are eroded rapidly by heavy rains. About 60 percent.
2. Clays and related highly cohesive soils, subject to erosion but not eroded so readily or destructively as the silts. About 15 percent.
3. Sands and similar light soils that have a high capacity for storing water and are only slightly subject to erosion. Nearly 10 percent.
4. Stony soils, occurring particularly in the mountain regions. Stone fragments sometimes form a heavy mantle on the surface of cleared land that greatly obstructs erosion. About 15 percent.

Forests that occur on sandy soils are in general classed as having a comparatively slight or at most a moderate influence upon watershed conditions, because these soils are highly absorptive even in the absence of a vegetative cover. Forests that grow on clay soils, as in the rolling hill lands of northern Louisiana, are for the most part classed as having a major influence because such soils are eroded so readily in the absence of cover.

FOREST COVER

The forest area in these drainages totals about 52 million acres, forming about one third of the total area. It has three parts. The Rocky Mountain area is relatively small, a narrow strip extending about 300 miles along the eastward front of the mountains. Most of this is in the Arkansas River drainage. The eastern forest area lies largely east of the ninety-seventh meridian. The central area, relatively small in extent, lies largely in the Breaks.

In the Rocky Mountain section dense forests of pine, fir, and spruce exist. On the poorer sites the forest is open. The foothills and mesas support only open woodlands of pine and cedar, in which grass is abundant.

In the Ozark-Ouachita section commercial forest occurs in the more humid eastern portion and the "fringe forest" in the western. About half the forest area of the Ozark-Ouachita section has now been cleared for agriculture.

The "fringe forest" is the rather scrubby forest and woodland that borders the commercial forest of the Ozark-Ouachita Mountains on the west. The Arkansas and Red River drainages contain about 10 million acres of woodland, of which Oklahoma has 7½ million acres. This woodland type, which reflects the dryness of the region, is composed largely of oak. Pine, mostly shortleaf, occurs on the better sites.

Within the plains region the woods occur as islands and stringers on the lighter soils and north slopes. Poplars and willows follow the streams far into the plains. The forest of the Breaks is largely woodland and brush, scrub oaks and brushy vegetation predominating.

Because the Arkansas and Red Rivers contribute great quantities of water and silt to the Mississippi floods, it is highly desirable in the drainages of these rivers to retard stream flow during the flood periods and to protect the soil from erosion. Watershed-protection service rendered by the forests in these drainages at critical periods is a matter of national importance.

The effectiveness of the forest cover in maintaining good watershed conditions is indicated at least in part by the behavior of the Current River, a northeasterly tributary of the White River. The upper part of the basin of this river is rough and hilly, the lower rolling. Most of it is in forest. The ordinary flow of the river is derived almost entirely from springs. Discharge measurements made by the Geological Survey show that, originating from deforested or burned areas, its ratio of maximum to minimum flow is only 65 to 1, whereas for the main Arkansas River at its mouth the ratio of maximum to minimum flow is 600 to 1.

WATERSHED PROTECTIVE CONDITIONS BY REGIONS

ROCKY MOUNTAIN FORESTS

In the Rocky Mountain part of the Arkansas and Red River drainages some timber has been cut but the relative inaccessibility of the forests has prevented extensive exploitation. Relatively few fires occur, though it is evident that fires have been severe in the past. In the spruce type fires have been particularly disastrous, many burns having failed to restock. Unrestricted grazing in the early days led to serious gullying of mountain meadows, which has not yet healed.

Some 80 percent, or about 2¼ million acres, of the forest area in this section is included in national forests. This acreage is protected from fire, and is so managed that cutting and grazing do not destroy the cover and that forest conditions are steadily improving.

Outside the national forests, forest land is not being given the care that its watershed values justify. Cutting has removed much of the forest cover, and recurrent fires destroy the litter. Loss of the litter has decidedly impaired watershed values, resulting in increased surface run-off, decreased absorption, and increased erosion. Overgrazing, typical of the foothills and lower slopes, has accentuated watershed damage. The stony soils are easily erosible. Erosion caused by too heavy grazing use progresses with special rapidity during severe rainstorms. Trout Creek, near Buena Vista, Colo., furnishes an outstanding example of the results of reduction of cover. Formerly this stream for 20 miles was clear and willow lined, and gave no evidence of erosion. Timber cutting in recent years has been followed by fire and overgrazing. The fertile bottomland soil has now been washed away, all the willows are gone, and the stream is imbedded in a deep, wide gully practically throughout its length. Heavy rains now cause floods which result in damage to agricultural lands and to transportation improvements.

OZARK-OUACHITA FORESTS

Lumbering on a large scale in the eastern mountains began about 1890. It was concentrated on the pine lands at first, but soon moved into the hardwoods. The first cuttings were usually light, but as time passed heavier cutting became the rule.

Slashings rarely escaped burning. Repeated fires gradually deteriorated the forest. In many places, especially on the poorer soils, the stands became more or less open or brushy. A recent study of hardwood stands on the Ozark National Forest by the Central States Forest Experiment Station showed that only 1.5 percent of the stands studied were of seedling origin.

Settlement in the Ozark-Ouachita region began about 1830. By 1860 the greater portion of the White River Valley of northern Arkansas and most of the Arkansas Valley to the Oklahoma line had been settled. The prairies and oak openings were first to be occupied. A great part of the alluvial and rolling hill land of the main Arkansas Valley has since been put into cultivation.

Clearing and cultivation of row crops on hillsides has led to rather general erosion as the humus in the top soil was exhausted or washed away, and to subsequent abandonment of crop lands. Many of the hill farms should never have been cleared. Census data show that the crop-land area in Garland and Baxter Counties of central Arkansas has declined by nearly one third, and that a similar decline has taken place in counties in the forest belt of southern Missouri and northern Louisiana. Serious erosion is occurring in the hill lands in northeastern Texas. Certain of the soil types, such as the loess found on Crowley's Ridge in northeastern Arkansas, are eroded rapidly into deep gullies that not only make further cultivation impossible but in many instances prevent reforestation. Fortunately the shortleaf pine of the mountains and the loblolly of the lower slopes and bottoms bear seed frequently and scatter their seeds widely, and thus quickly reclaim abandoned fields. In many cases, however, fires on the restocking fields prevent maintenance of the good forest and litter cover so necessary to proper watershed conditions.

In Arkansas, which lies almost entirely in the Arkansas and Red River drainages, the average area burned over annually in the 5-year period 1926–1930 was some 2,350,000 acres of a total forest area of 22 million acres, this burned area including 2,190,000 acres of the unprotected forest area of 18½ million acres. Cutting and fire together have deteriorated the forest on approximately half the total forest area of Arkansas. On some of these lands there is a brush or other low type of cover, but frequent fires prevent the development of a good litter cover.

For the Ozark-Ouachita section as a whole, grazing is not a factor of great importance in watershed conditions. Some hardwood forests are grazed, with consequent opening of the stand and dissipation of the litter. Cattle are turned loose on pine lands, also, especially in the Kisatchie Hills section of northern Louisiana, but not in sufficient numbers to create critical conditions through depleting the minor vegetation. The practice of burning for the purpose of range betterment is the most serious factor connected with grazing.

FRINGE FOREST

In Missouri, Oklahoma, Kansas, and northern Texas, extensive areas of woodland have been cleared for agriculture. As settlement increased the practice of burning the woods became prevalent. Under burning, humus conditions deteriorated and the perennial herbs gave way to annual grasses. Overgrazing, also, has greatly depleted the vegetative cover and in the stands thus opened litter cover cannot form because winds scatter the leaves.

The extent of fires in the fringe forest type is indicated by fire records for Oklahoma, where the fringe forest makes up about two thirds of the total forest area. The records do not separate the woodland type from the commercial forest, but probably at least half and possibly two thirds of the fires recorded occurred in the woodland type. In 1931, 7,600 forest fires in Oklahoma burned almost 2½ million acres of the 12½ million acres of forest land in the State and did damage to the extent of more than $3,000,000. This damage estimate takes no cognizance of watershed values impaired or destroyed.

The effect of fire in this type is shown by investigations recently made at the Red Plains Erosion Experiment Station, near Guthrie, Okla., which are described in detail in the discussion, "Consequences of Disturbing the Forest Cover." These investigations showed that the run-off from a burned plot of post-oak timber was more than 110 times as great as the run-off from a similar unburned plot. Erosion similarly removed 15 times as much soil from the burned area. Although the litter found in post oak woodland is not so dense or so effective in limiting run-off as that in forests of many other species, in this experiment it showed great value for flood control.

Erosion is common on the upland cultivated soils, especially on those that are hilly or rolling and not terraced. As a result of this erosion heavy silt loads are carried by the streams of southwestern Missouri and eastern Kansas. Of the two Hanceville soil types the State forester of Oklahoma said: "Much of the land when cleared is so subject to erosion that only a comparatively few crops can be raised before it has to be abandoned." In the Wichita and Arbuckle Mountains of central Oklahoma, agriculture on steep hill lands has caused both sheet and gully erosion. Many of the eroded lands have been abandoned. On these lands a forest cover is slow to return.

In 1930 an erosion survey by the Oklahoma Agricultural College disclosed that of the approximately 16 million acres of cultivated land in the State 13 million acres was subject to excessive washing, 6 million acres had reached the gullying stage, and 374,000 acres was so badly gullied that farm machinery could not be used on it. The survey revealed also that in the preceding 3 or 4 years 1,359,000 acres of formerly tilled land had been abandoned because of erosion.

BREAKS FORESTS

In the Breaks sparsely wooded, brush-covered, or even naked slopes occur in the gorges of the Arkansas and Red Rivers and their tributaries. In many places the vegetation is in such delicate balance that any disturbance results in extensive gullying. Erosion has been intensified by the torrential character of the rains, and has been accelerated by overgrazing.

Erosion from the Breaks probably accounts for two thirds of the silt load of both rivers.

WATERSHED-PROTECTIVE CONDITIONS BY TYPE OF LAND OWNERSHIP

NATIONAL FORESTS

The value of the forests in the Arkansas and Red River drainages has been recognized by the Government through the establishment of national forests, which include much of the headwaters forest area in the Rocky Mountains, and through plans for national-forest extension. On these national forests, conditions resulting from overgrazing are being corrected through range management, methods of cutting timber that provide for restocking are in effect, and fire control is on an organized basis. Watershed conditions are therefore improving. In the Ouachita-Ozark highlands, the national-forest area amounts to some 1,250,000 acres. Here, likewise, measures have been put into effect to restore the forest cover where it has been depleted and to protect the forests from fire, and timber cutting is regulated.

PUBLIC DOMAIN

Some 770,000 acres of unreserved public-domain forest land still exists in these drainages, mostly woodland areas at the headwaters of the rivers. Conditions are less satisfactory on these lands than on the national forests, because management is lacking. The Forest Service recommended to the Public Domain Commission in 1930 that many of these lands be added to existing national forests.

STATE LANDS

State ownership of forest land in the Arkansas and Red River drainages covers only 105,000 acres. Most of the State forest lands are so located and in such small units that adequate management is practically out of the question. They are consequently in about the same condition as private lands.

PRIVATE LANDS

Private owners of forest lands, for the most part, have not concerned themselves with maintaining good watershed conditions on their holdings. A number of owners are endeavoring to protect their lands from fire, but this effort is not general; in 1931, fire protection was afforded for only 17 percent of the privately owned forest area of

Oklahoma and Arkansas. Some companies owning extensive tracts of timberland in Arkansas and Louisiana have purchased the lands of settlers believed to be responsible for frequent fires.

Some landholders are cutting their timber in such a way as not to cause deterioration of the stand and on a continuous-production basis.

Much idle farm land is potential forest land, since it is at least exceedingly doubtful that it will again be needed for crop production for many years.

MEASURES NEEDED FOR WATERSHED PROTECTION

In the Arkansas and Red River drainages the adoption of adequate fire-control standards such as are outlined in the section of this report entitled "Protection Against Fire" would better watershed conditions more quickly than any other measure. Adoption of simple forestry practices would contribute greatly to the improvement of watershed conditions. These would include better cutting practices and the elimination of grazing from cut-over hardwood areas—at least until the forest cover has reestablished itself. Clearing of hills that are too steep for profitable cultivation should not be permitted. The present widespread erosion of hill crop lands and the increasing abandonment of these lands indicate that cultivation of slopes the grade of which exceeds 12 or 15 percent is uneconomic except under most unusual circumstances.

Forest planting is needed to supplement natural restocking, on abandoned agricultural lands and on some forest lands. Some 500,000 acres in the Ozark-Ouachita highlands and about 250,000 acres in the upper coastal plain region should be reforested.

Special measures of erosion control and probably of water control are needed on many areas. These would include such devices as soil-saving dams on badly gullied abandoned agricultural lands, check dams on mountain areas to assist in holding back the surface flow, terracing of some of the most severely eroded abandoned agricultural lands, sodding of some particularly bad areas, and streambank correction to prevent undercutting.

In the Breaks areas, grazing, which is probably more responsible than any other factor for extensive erosion, should be more closely regulated. Much can be done to control severe washing and gullying by such devices as check dams, erosion fences, etc. Such devices can only be of lasting benefit if cover conditions are properly maintained. Investigation should be made into the possibility of reducing by range management, tree planting, reseeding of depleted range land, and special erosion-control measures the quantity of silt added by this area to the burden of the Arkansas and Red Rivers.

In these drainages satisfactory cover conditions might be expected to result from extending to the unreserved public domain and to private forest lands the practices now in effect on the national forests. It is doubtful that the private owner can undertake to put these measures into effect. Forest planting, elimination of grazing, and other needed erosion-control measures would result in heavy charges against the land. For this reason, and in view of the relationship between forest conditions in these drainages and the floods of the lower Mississippi, public ownership of about 19.2 million acres in the drainages appears desirable. This will include about 2.2 million acres of abandoned agricultural lands and 17 million acres of forest land. The very large national interest created by conditions in these drainages suggest that this public ownership be Federal rather than State or other local.

LOWER MISSISSIPPI RIVER BASIN

Floods in the Mississippi Valley are most common and of greatest concern in the "Delta" or bottomland region of the lower Mississippi Basin. Here all the major tributaries of the big river pour in their flood contributions, the control of which constitutes the outstanding flood problem in the United States. Responsibility for the havoc wrought by floods in the bottomlands of the lower Mississippi Basin must be attributed largely to flood waters from other sections. However, were the latter all under control, there would still be a local flood problem of considerable magnitude in the lower Mississippi Basin as a result of the condition of its watershed and the relatively large area of alluvial bottomlands on which its own flood waters are poured.

LOCATION AND DESCRIPTION OF DRAINAGE BASIN

For purposes of this discussion, the lower Mississippi Basin (shown in fig. 6) includes not only the alluvial lands extending from Cairo, Ill., to the Gulf of Mexico but also the upland watersheds of the streams draining directly into the lower river. These are small and relatively unimportant streams with the exception of the Yazoo River which heads in the uplands of north-central Mississippi and flows over a wide alluvial flood plain to join the Mississippi River at Vicksburg.

The lower Mississippi Basin is from 500 to 600 miles long and up to 150 miles wide. It has a total area of 33,886,000 acres. Nearly one half the total area is in overflow bottomlands. Here forest occupies lands not protected by levees and lands behind the levees which have not been cleared for agriculture. These overflow areas are often covered with water during the winter season and thus perform an important service in flood control since they serve as natural storage reservoirs for the detention of flood waters.

The remainder of the drainage basin consists of rolling to hilly uplands. The principal area—the Mississippi bluffs and silt loam uplands—borders the Mississippi Delta on the east and extends in a strip 35 to 100 miles wide throughout the length of the drainage basin. A much smaller but similar upland area known as Crowley's Ridge is located west of the Mississippi River. The latter area occupies a narrow belt up to 10 miles wide and about 200 miles long and rises about 150 feet above the level of the surrounding bottomlands. Also included in the drainage is a relatively small area of hilly country in southeastern Missouri.

These uplands because of their location with reference to low-lying bottomlands and because of their present condition play an important part in the destructive floods and soil erosion that are the major watershed problems of the drainage.

STREAM FLOW AND FLOOD PROBLEMS OF THE DRAINAGE

As has been pointed out, major overflows in the Mississippi Delta have their source outside the boundaries of the drainage basin. In the lower Mississippi Basin the outstanding flood problem directly attributable to run-off from within the drainage occurs in the Yazoo Delta. This is an alluvial flood plain 180 miles long and up to 65 miles wide, lying between the Yazoo and Mississippi Rivers north of their confluence in western Mississippi. Here major floods occur periodically every few years, frequently during the winter months after heavy and prolonged rains. They originate in north central Mississippi on the watersheds of upland tributaries, and are the result of surface run-off from the uplands poured quickly and in large volumes on a region of nearly level topography and poor drainage. These overflows often cover hundreds of thousands of acres and do widespread damage. The most recent Yazoo flood occurred during the period December to February, 1931–32. This overflow, the greatest on record, inundated some 600,000 acres and imposed great hardships. According to estimates of the United States Weather Bureau, it resulted in property damage of almost $1,500,000, not including the damage to crops and livestock.

Floods of less magnitude occur on the bottomlands of other streams draining the uplands of the lower Mississippi Basin. These streams have a low gradient and are rather sluggish. Some have developed flood plains several miles in width and these are flooded almost annually during periods of heavy rainfall. On these bottomlands, the most disastrous floods occur during the summer months when heavy rains produce overflows that inundate growing crops.

Although the normal discharge of these streams is slow, discharges at flood are turbulent. Even at normal flow the water is strongly discolored and carries large volumes of silt. In addition, flood waters transport enormous quantities of heavier materials and, during periods of overflow, often cover productive alluvial farm lands with an infertile blanket of sand and gravel. The channels of creeks and other small tributaries are frequently filled with such detritus, thereby causing more frequent and extensive overflows on adjacent bottomlands. The sediment carried by the headwater drainages becomes of greater economic concern when it reaches navigable streams and is deposited in the channels, thus necessitating costly dredging operations. In 1931, such work in the Memphis district of the Mississippi River cost nearly $800,000. For the lower river as a whole it has cost to date some $19,000,000 to remove soil eroded from the watersheds of the Mississippi River system.

The streams of the lower Mississippi Basin are perennial and flow throughout the year. The flow, however, is not uniform and is particularly erratic for those streams draining only upland watersheds. Irregularities in flow are indicated by stream gage records of the United States Geological Survey which show, for the Coldwater River, a ratio of maximum to minimum discharge of 725:1; for the Yallobusha River, 486:1; and for the Yazoo River 43:1. The erratic behavior of these streams in common with others in the basin is evidenced during periods of heavy and prolonged rainfall when rises are comparatively rapid. Flood stages are often reached in a few days and subsidence occurs just as quickly when the bulk of the surface water has drained away.

CHARACTER AND CAUSES OF EROSION

While erosion problems are confined to the upland portions of the drainage basin they are intimately related to the flood and stream-flow problems of the lowlands since both are quite largely the product of uncontrolled surface run-off. That the uplands of the basin are especially susceptible to erosion is shown by the results of surveys made in 1930 by the Southern Forest Experiment Station. These reveal that 28 percent of the entire upland area in northern Mississippi is denuded land, barren of cover and actively eroding. In 4 counties more than 30 percent of the total area is eroding, while in 2 more than 40 percent is so classed. An additional area of 27 percent of the region is abandoned land, the abandonment of which in part was caused by soil impoverishment. These data apply specifically to the upland watersheds of the streams tributary to the Yazoo River, but the widespread and destructive soil destruction found in this portion of the Mississippi silt loam uplands characterizes a large part of the entire region.

A mere quantitative estimate of erosion, however, gives little indication of the real seriousness of the problem. Much of the erosion is of a peculiarly destructive type. Washes 20 to 30 feet in depth are common and occasionally gullies nearly 100 feet in depth are found. Such erosion has made these silt uplands and their counterpart in the upper Mississippi drainage, a region of outstanding watershed and erosion problems.

A combination of factors is responsible for the serious erosion and flood problems of the region. The precipitation is heavy and averages, for the region, between 40 and 55 inches, more than half of it falling when the cultivated lands are bare of cover. Most of it comes as numerous rains, frequently torrential in character. According to United States Weather Bureau records, there have been about 35 days annually over a 20-year period with rainfall of one fourth inch to 1 inch and about 4 days with rains of 2 inches and over. A maximum precipitation of 4 inches an hour and 9 inches in 24 hours is reported.

The soils of the region are highly erosible and consist mainly of silt loams and clay loams derived from loess. When protected by forest or other vegetative cover these soils do not erode easily and are capable of absorbing large quantities of rainfall. When bared, however, they wash badly. The silty soils are frequently underlain at depth of a few feet by unconsolidated sands and other incoherent materials. Once a gully has cut through the surface loams and exposed these unstable strata, erosion proceeds on a gigantic scale, and is extremely difficult to control.

The unwise use of these uplands for agriculture is responsible for practically all of the soil wastage that has occurred. The cultivation of cotton and corn to the exclusion of other crops leaves the soils exposed to the action of the elements during much of the year. Even on moderate slopes the soil losses from the cultivated fields of the region are enormous. Forest Service studies at Holly Springs, Miss., show that a single rain falling on a cornfield having a 10 percent slope washed soil from a study plot at the rate of 23 tons per acre. Preliminary results also show that under such conditions only 2 to 3 years are required to wash away 1 inch of topsoil These data, substantiated by observations, indicate that the cultivable life of these upland soils ranges from 5 to 20 years.

As a result of such conditions, wholesale abandonment of farm lands has occurred. The surveys of the Southern Forest Experiment Station indicate that on the upland watershed of the Yazoo River, totaling roughly 3,487,000 acres, there are 813,000 acres of abandoned farm lands and almost as large an area additional of land formerly abandoned but now used for pasture. More intensive surveys of five farms also show that more than 50 percent of the total area of each farm had been abandoned because of erosion. The abandonment of eroded marginal lands is an important factor in the growth and spread of gullies which usually proceed unchecked once the fields are taken out of cultivation. Unless control measures are promptly taken, complete destruction of the abandoned field results.

RELATION OF FORESTS TO FLOOD AND EROSION PROBLEMS OF THE DRAINAGE BASIN

The original forest of the uplands was largely mixed pines and hardwoods. In the southern portion of the region loblolly pine is predominant and seeds in abundantly on waste and abandoned areas. In northern Mississippi shortleaf pine occurs in mixtures with the mixed oak forest. Further north, the forest consists almost entirely of oak, hickory, and other hardwoods.

Clearing, primarily for agriculture, has been extensive. Less than 25 percent of the uplands area originally completely timbered is still in forest.

Lumbering is now of minor consequence in this region. In the past, cutting as a rule was not heavy, and stands were culled of their large white oak, yellow poplar, and other desirable species, rather than cut clear. Later cuttings for ties and other minor products have seriously depleted the stands. Logging seldom produced devastation consequently, unless the logged-over area were put into cultivation, protection values were little changed. Within the range of the pines, cut-over areas reseed within a few years as a rule and reproduction becomes established in spite of fire and other mistreatment. Hardwood stands are rarely cut clear and reproduction is usually complete.

Fire is a much more serious factor than cutting, because fires, often purposely set, burn over extensive areas of forest annually. Litter accumulations, so necessary to good watershed conditions are thus prevented, and in those areas where repeated fires occur at short intervals, the forest often has greatly deteriorated.

Grazing is typically a woodlot problem, although in some localities the stock is turned loose in the woods. Most of the really serious damage to the forest is done in cut-over hardwood stands where repeated browsing of the new growth tends towards the formation of brushy stands or in some places rather open woods.

It is estimated that in the entire lower Mississippi Basin there are approximately 17,854,000 acres of forest land, of which roughly 6,857,000 acres have a major influence on watershed values and 1,877,000 acres have a moderate influence. The relative influence ascribed to each class of forest is based largely on the location of the forest with respect to regions where conditions are particularly conducive to excessive surface run-off and erosion. The forests of each protection class are shown in figure 6.

The forests having a moderate and heavy influence are in the silt loam uplands, Crowley's Ridge, and the hill lands of southeastern Missouri. However, only 25 percent or less of the total area of these erosive uplands is now forested. Therefore, if the protective influence of forest is to be more fully realized there should be marked extension of the present forest area and the restoration of forest cover to large areas of now idle land. Such upland forests as remain afford somewhat less than the maximum possible protection, but they unquestionably exert a considerable and beneficial influence on erosion and on stream flow. In the Yazoo River flood period of 1931–32, the Southern Forest Experiment Station found that of the 27 inches of rain that fell, 62 percent ran off cultivated fields immediately and carried soil with it at the rate of 34 tons per acre. In barren abandoned fields the run-off was 54 percent of the total rainfall. During the heaviest rains from 75 to 95 percent of the rain falling on these classes of land became surface run-off. On the other hand, of the 27 inches of rain falling on an undisturbed oak forest, less than 0.5 percent ran off the surface, taking only about 75 pounds of soil per acre. The run-off from a plot located in a scrub-oak forest, and with a litter cover, was 2 percent of the rainfall.

For the period of observation, the surface or flood run-off from land in cultivation was 127 times greater than from forest land, and the eroded soil over 900 times greater.

WATERSHED AREA IN NEED OF SPECIAL ATTENTION

As the upland area of the lower Mississippi Basin has such an intimate bearing upon floods and upon the amount of eroded material which reaches the Mississippi River, it is one of the outstanding critical areas of the country, one in which every effort should be made to bring about more favorable conditions.

Of these uplands, the situation in the Yazoo River drainage probably is in most need of early attention. From this unit of roughly 3,487,000 acres gross, surface run-off is quickly concentrated in drainage channels and the flood waters are almost immediately debouched into the low-lying, poorly drained Delta where extensive areas of true agricultural land are subject to destructive inundation as the result of unwise land use in the adjacent uplands. Residents of the Yazoo Delta, one of the most productive of all agricultural regions, with half of its nearly 6 million acres in fertile farm lands, have made numerous demands for the construction of a complete system of levees, which would protect them not only from the Mississippi floods but also from those of the Yazoo as well. Engineers estimate, however, that adequate levee protection from floods would cost many millions of dollars. In this whole situation lies strong evidence of a need rather to control run-off at its source through changes in land utilization in adjacent uplands.

Something like 35 percent, or 1,214,000 acres, of the Yazoo uplands are in cultivated crops. This large area appears to be a serious obstacle to any program aimed at complete control through forest cover.

Of the cultivated area, the data indicate that about 470,000 acres, or 13 percent of the total, is badly sheet eroded and hence will quite likely be worn out and abandoned within the next 10 or 15 years. These eroded submarginal lands could very easily be converted into forest or pasture if remedial steps were taken promptly at time of abandonment. Unless a vegetative cover is quickly established, uncontrolled run-off soon transforms these old fields into gullied wastes which are difficult to reclaim. An additional 350,000 acres of eroded pasture land will quickly revert to forest or other native vegetation if protected from livestock.

Of the total area of the Yazoo upland watershed, 23 percent, or about 813,000 acres of once arable land, has been abandoned and is now lying idle. Of this area about 500,000 acres is not seriously eroded and is reverting naturally to forest and grasses. The remaining 313,000 acres is, however, very badly gullied and actively eroding. The preliminary run-off studies in northern Mississippi indicate that the areas which are or have been in cultivation are the outstanding contributors of flashy run-off and suffer most of the soil losses. As the badly eroded and impoverished abandoned lands will not revegetate except after a long period, it will be necessary to establish the forest cover largely through artificial means. About 250,000 acres probably need planting, many of which need special erosion-control measures as well.

The planting of these severely gullied lands offers many difficulties that are at present being investigated. In certain cases, however, such plantings have already proved successful and practicable. In western Tennessee, black locust plantations have been established on many eroded fields. These plantations in 10 to 15 years have not only effectively stopped erosion but have developed such a cover that soil and water conditions approach those of a much older forest.

Plantations alone cannot stop the further extension of gullies. They are too deep and the erosive processes are taking place too rapidly. Special works, such as soil-saving dams and check dams, are needed. Seeding and sodding of slopes will be required. Probably 150,000 acres in all will require special treatment. The upland types receive little fire protection. Adequate fire control would permit many abandoned lands to restock fairly promptly and would enable the restocking lands to develop a denser cover. It would also permit the formation of a good litter layer.

Erosion on the areas in need of planting has already progressed far beyond the stage where the land can be again reclaimed for cultivation. Furthermore, from 65 to 85 percent of the farm lands, according to 1930 census figures, are in the hands of tenant farmers who have little incentive for improving them inasmuch as the absentee owners are, as a rule, indifferent to their destruction. At the present rate of abandonment, it seems highly probable that in 10 or 15 years less than 25 percent of the uplands area will be in cultivation, provided that new areas are not cleared nor old fields again put into cultivation.

At the present time practically all of the silt loam uplands are in private hands. In view of local conditions and the abandonment of agricultural lands, it appears unlikely that watershed conditions can be corrected through the efforts of the private owners. These efforts would place a heavy financial burden on the owner and most of them do not hold out to him the possibility of monetary return. Public acquisition of a large area therefore seems certain, and, in view of the national interest involved, Federal participation may be called for.

Study of the watershed needs in the lower Mississippi River Basin leads to the belief that some 5.8 million acres should be in public ownership. Of these 1.2 million acres are classed as abandoned and eroded agricultural lands and 4.6 million acres as forest lands. All of this land is in the region having a major influence on streams. Public ownership and management of these lands will assist greatly in restoring more favorable conditions of water flow.

CALIFORNIA DRAINAGES

An honorary watershed committee appointed by the Governor of California, in a report published in 1932 under the title, "Forestry in the State-Wide Water Plan", states: " * * * the best possible development and conservation of the waters of the State are of the utmost importance to the continued prosperity of both the rural and urban communities of California." In this committee's opinion "any great increase in population in this State is impossible without the fullest feasible conservation of its waters. Without a sound program of water conservation * * * California cannot continue to maintain even its present population."

The California drainages (fig. 11) as here considered include all lands in the State except the eastward slope of the Sierra Nevada, which drains into the Great Basin, and include also portions of Oregon that are drained by the Klamath and Sacramento Rivers. According to the 1930 census these California drainages include 4,765,000 acres of irrigated land, and the value of this land, together with that of improvements and equipment and of irrigation enterprises serving the land, totals nearly $3,000,000,000. This high value is due to conditions favorable to production of high-value fruit and other crops on a considerable part of the irrigated land. The very large urban population of the drainages makes a heavy demand for water for municipal use. In waterpower development California ranks first among the States, with a present installed capacity of 2,321,374 horsepower which has been yielding an average output of about 1,173,000 horsepower. It is expected that ultimate development will raise the average output to 6,674,000 horsepower available 50 percent of the time.

In order most effectively to develop and conserve its water resources California has developed a State water plan that calls for expenditure of approximately $500,000,000 in constructing reservoirs and canals. The proposed reservoirs would be located largely in the foothills of the Sierra Nevada with a view to impounding flood waters from the higher watersheds, and the canals would transport water from areas of surplus to areas of inadequate supply. The water shortages which this plan is designed to overcome in part occur principally in the San Joaquin River Basin.

The State watershed committee estimates that the mountain and foothill areas upon which the valleys and lowlands depend as their source of water aggregate some 40 million acres, approximately 40 percent of the total land area of the State. Effective precipitation occurs on these areas during a period of about 5 months in the winter and early spring. Summer rains are not uncommon in the northwest coast belt and in the Sierras but are extremely rare in the other parts of the State. Furthermore, summers are hot. Precipitation occurs below the 2,500-foot contour as rain, between the 2,500-and 5,000-foot contours as rain and snow, above 5,000 feet as snow. Annual precipitation totals 50 inches or more in the northern Sierra Nevada and in the northern coast ranges. It gradually decreases toward the south. Likewise the proportion of the precipitation that accumulates as snow in the mountains decreases toward the south. In view of the long, dry summers and the present incomplete development of reservoir storage the heavy winter snow pack, especially in the Sierras, is

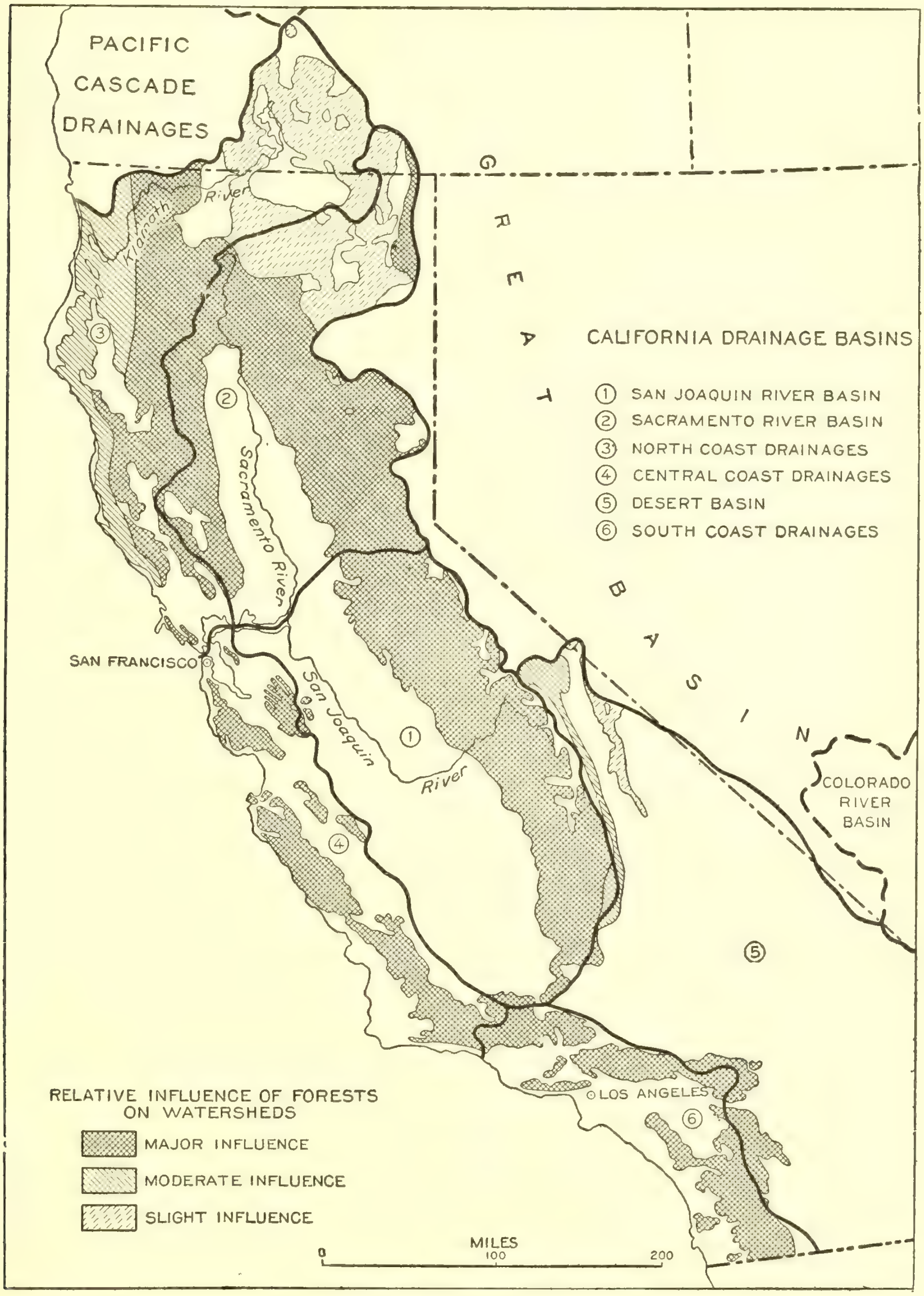
PACIFIC CASCADE DRAINAGES
GREAT BASIN
Klamath River
Sacramento River
San Joaquin River
SAN FRANCISCO
LOS ANGELES
COLORADO RIVER BASIN
CALIFORNIA DRAINAGE BASINS
① SAN JOAQUIN RIVER BASIN
② SACRAMENTO RIVER BASIN
③ NORTH COAST DRAINAGES
④ CENTRAL COAST DRAINAGES
⑤ DESERT BASIN
⑥ SOUTH COAST DRAINAGES
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
MILES
0
100
200

FIGURE 11.—California drainages.

of the utmost importance to both power and irrigation interests. Run-off from snow melt at the higher elevations remains plentiful well into July, and a rather well-sustained flow continues through the summer in many of the streams from drainage of water that has seeped into the soil. Upward of 2,500 mountain meadows and 1,500 lakes act as natural storage basins helping to maintain this stream flow.

The mountain areas are largely forested, chiefly with conifers. Interspersed with the coniferous forests are extensive brush fields, many of which, under proper management, could be converted again into coniferous forest. The foothills are covered mainly with brush and chaparral, with lesser areas of woodland and grassland. As a whole the forests of the California drainages amount to approximately 29,780,000 acres, this total including timberland, woodland, chaparral, and brushland.

While the bulk of the forest lands are still virgin, extensive areas show the effects of destructive fires to which they have been subjected in the past and of destructive lumbering. The foothills, in particular, have suffered disastrously from fire. Overgrazing, also, has seriously injured the watershed cover of forested lands.

Destruction of watershed cover has resulted in abnormal erosion over millions of acres, particularly in the foothill belt. The eroded material is rapidly silting up reservoirs, canals, ditches, and other engineering works, shortening their life or adding to the cost of maintenance far beyond what silting from normal erosion would do. Eroded material also seals the surface soil of gravel beds at the mouths of canyons over which run-off water is spread in order to increase storage in subterranean basins. This method of increasing water storage is used extensively in southern California. The silting up of these gravel beds retards the salvage of flood waters. The heavy draft on underground water supplies is lowering the water level and increasing the cost and difficulty of irrigating from wells.

The eroded material, added to the rapid run-off from exposed slopes, greatly intensifies the destructiveness of floods. In 1928 North Sacramento and other towns of the Sacramento Valley suffered a loss of $736,000 as a result of floods in the Mokelumne, Consumnes, American, and Feather-Yuba Rivers.[67] Destructive floods have occurred in many parts of the State.

FOREST COVER IN RELATION TO WATERSHED PROBLEMS IN INDIVIDUAL DRAINAGES

On the basis of watershed problems and the relation of forest cover to them, the California drainages logically divide into six units: (1) The San Joaquin River Basin; (2) the Sacramento River Basin; (3) the north coast drainages, including that of the Klamath River; (4) the central coast drainages; (5) the desert basin; and (6) the south coast drainages. These units differ as to physical and other factors contributing to the influence of forests upon water supply, erosion, and floods, as to the demand for water, and as to other watershed considerations.

California watershed lands are chiefly of three classes—forest, range, and agricultural. It is probable that erosion and the influence of run-off on floods is more serious on range and sloping agricultural lands than on forest lands. This discussion covers forest land, range and agricultural lands occurring within the forest in such a way that the watershed relationships cannot be effectively separated, and lands cleared of timber that should have remained forested. The following discussion of forest conditions and use will deal both with the timber and its use by cutting and with the forest-range plants and their use by grazing. Destructive factors such as overcutting or improper logging, fire, and overgrazing are considered, as they influence both the timber and the understory of other vegetation.

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[67] Taylor, N. R. "The Floods of March 1928, in the Sacramento Valley," pp. 100–102. Monthly Weather Review, March 1928.

SAN JOAQUIN RIVER BASIN

Water is in especial demand in the San Joaquin River Basin, which includes together with the broad San Joaquin Valley many westward drainages from the southern half of the Sierra Nevada and a narrow strip of the eastern part of the Coast Range. Approximately 2,405,380 acres are now irrigated and a total of 3,773,964 acres is irrigable. The Hetch Hetchy project, costing $126,500,000, is designed to provide San Francisco and its environs (1930 population, 634,394) with an adequate water supply drawn from the Tuolumne drainage of the Sierra Nevada. Many valley towns and cities, also, depend upon the forested watersheds of this basin for their water supplies. Numerous power plants have been developed or are contemplated. On the whole, the water supply is inadequate.

Toward the southern part of the basin the water shortage is intense. The State water plan proposes to augment supplies in that part from those farther north, through the construction of reservoirs in the Sierra Nevada foothills and of canals to transport the water.

Approximately 22 percent of the basin's area is occupied by coniferous forest, which occurs in a belt along the west slope of the Sierra Nevada. It is from this belt that most of the water comes. The 40 to 50 inches or more of precipitation in the northern part and the 20 to 30 inches in the southern part occur chiefly as snow, which accumulates, particularly in the northern part, in such a way as to furnish large reserves for summer flow. In the main, timber stands are dense and there is a good litter cover which, together with undergrowth, completely covers the soil. Accordingly, snow melt is retarded and there is good absorption into the soil. Normal erosion of the soil, which is derived largely from granitic rocks, does not exceed soil formation unless the cover of vegetation is removed. All this area has been classed as of major watershed influence. In the heavily forested belt, which is chiefly included in national forests or national parks, watershed conditions are generally good. National-park management aims to keep the forest in as natural a condition as possible, and national-forest lands are administered to maintain watersheds in the most satisfactory condition feasible.

In the foothills where the woodland and brush types occur, an exploratory survey by the Forest Service indicated that abnormal erosion is very serious even though rainfall totals only 15 to 25 inches. Much of the woodland and brush area has passed into private ownership, although parts of it remain as unappropriated public domain. Fire is the greatest threat to the woodland cover. A great part of the foothill belt is burned yearly. Many fires are set by stockmen in the belief that fire will keep the brush cover open and improve grazing or by owners for the purpose of clearing land. The effect of destroying cover by fire has been excessive loss of soil from heavy rains. As was stated earlier in this section, this loss amounted to 4 cubic yards of soil per acre on experimental plots near Northfork during one winter rainy period, during which only the barest trace of detrital material was washed from adjacent unburned woodland plots.

Woodland areas in the foothills furnish winter grazing for herds that occupy higher range during the summer months. Long, dry summers normally make it difficult for forage to grow, and the recent series of dry years has so depleted the forage cover on these vital watersheds that the problem of range feed supply and erosion control has become alarming. Studies recently begun in the foothills by the Forest Service are indicating why overgrazing has often been destructive to forage and watershed values there. Annual plants begin growth immediately following the start of winter rains, and livestock are usually placed on the range at that time. Growth in early winter is extremely slow; and the scant vegetation, depleted by overgrazing, does not effectively protect the soil against erosion from heavy rains. In addition, accelerated erosion has resulted from the clearing for agricultural development of certain sloping lands that should have remained in woodland. Because of the great danger of erosion when the vegetation is depleted, and the seriousness of the erosion damage to irrigation enterprises as well as of loss of soil productivity on the eroded lands, woodland and brush areas in the foothills have been classified as of major watershed-protective influence.

SACRAMENTO RIVER BASIN

The broad, rich, irrigated Sacramento Valley is bordered by mountains rising in a semicircular belt. Precipitation in the mountains is heavy, in general, occurring largely in winter as snow which at the higher elevations accumulates to considerable depths. Over most of the westward slopes of the Sierra Nevada, annual precipitation varies from 40 to 75 inches. On the plateau area in the northeastern part of the State drained by the Pitt River it varies from 15 to 35 inches. Along the east slope of the Coast Range it varies from about 20 to 35 inches. The melting of heavy snows furnishes abundant run-off for irrigation and power, especially in the spring and early summer. Rapid melting of the snow pack or heavy rains may cause damaging floods; for example, as has previously been mentioned, the March 1928 floods in the Sacramento Valley caused a loss of $736,000.

About 40 percent of the Sacramento River Basin is occupied by a dense forest of conifers. This coniferous forest develops a thick ground litter of needles and twigs. A rather dense stand of undergrowth, largely brush, also occurs. Where the vegetative cover has not been devastated by fire, destructive logging, or excessive grazing, it is effective in regulating run-off, and especially in preventing erosion, and is classed as of major watershed influence. On areas covered with partly decomposed lava and largely level, especially on the plateau in the northeastern part of the State, moisture readily penetrates the soil and the danger of serious erosion is slight. On such areas the forest, which is largely ponderosa pine, is considered to influence watershed values but slightly. Much of the Coast

Range area is covered with soils derived from sedimentary rocks such as sandstones and shales, which absorb water slowly and when exposed are readily eroded. Soils in the Sierra Nevada derived from lavas and basalts also are easily eroded when well decomposed. On soils of these classes the forest exerts a major watershed-protective influence by facilitating penetration of water from the heavy snow blanket and by controlling erosion.

In the Sacramento River Basin as in the San Joaquin Basin, the woodland and brush areas have been classed as having a major watershed-protective influence. The woodland and brush types occupy nearly 25 percent of the area of the basin. Where dense, the brush type forms a heavy mulch of litter on the soil, which retards run-off and erosion principally by maintaining the soil profile at its maximum absorptive capacity, its own absorption of water being a minor factor. Unfortunately from the standpoint of watershed protection, the owners of most private lands use fire to clear them or open the brush. On sloping lands, destruction of the cover is nearly always followed by severe erosion.

Erosion control is particularly necessary in this basin because of the importance of the reservoirs planned for the foothill belt under the State water plan. There is grave danger that the largest of these, the Kennett Reservoir in the upper Sacramento Basin, would fill with silt very rapidly. On an area near Kennett, where smelter fumes have caused complete destruction of all vegetation on upwards of 67,000 acres and partial destruction on 86,000 acres, "the hills are everywhere cut and gashed by the long furrows which run from practically the top of the hills to the bottom in straight lines, growing deeper and wider as they near the watercourses, which formerly were forest-lined, and now are gravel washes in the summer and torrents during the winter".[68]

NORTH COAST DRAINAGES

The north coast drainages extend northward along the Coast Range from San Francisco Bay and include the Klamath River, which drains a small part of southwestern Oregon east of the Cascades. Coniferous forest occupies more than 55 percent of the area of these drainages. Woodland occupies more than 15 percent of the area. Although precipitation in the upper reaches of the Klamath River watershed is about 20 inches or less, at some places along the Coast Range precipitation reaches 80 to 100 inches, the highest in the State. Most of this precipitation comes in winter, and at the higher elevations snow accumulates to considerable depths. Since precipitation is heavy, the forest cover good, and the demand for water relatively light, there is a considerable surplus of water over much of the drainage area, although in parts, such as the upper Klamath River, storage is necessary to assure a sustained supply. In this upper Klamath River area open volcanic soils absorb water so readily that the forest exerts only a slight influence on watershed values.

In the Coast Range serious erosion is possible, because of the heavy precipitation, steep slopes, and soils that are eroded readily when exposed. Very severe sheet and gully erosion is occurring, for example, on slopes cleared for cultivation. Most of the higher Coast Range forest areas have been considered as having a major watershed-protective influence. Areas classed as of moderate influence are those draining more directly into the Pacific Ocean.

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[68] Munns, E. N. Erosion and Flood Problems in California. Calif. State Board of Forestry Rpt. to the 1921 Legislature on S.Con.Res. 27. 1923.

CENTRAL COAST DRAINAGES

Coniferous forest occupies less than 8 percent of the central coast drainage area, which extends along the Coast Range from San Francisco Bay to about 20 miles southeast of Santa Barbara. The coniferous forest is largely confined to areas near the coast where precipitation is rather heavy, averaging 25 to 40 inches annually. The woodland and brush types occupy approximately 40 percent of the drainage area, in general the portions where precipitation averages from 15 to 25 inches annually. They cover the bulk of the steep Coast Range slopes.

Demand for water for municipal and domestic use is heavy. It is from the northern part of this basin, the Spring Valley development, that San Francisco obtains a large part of its water supply. Many communities depend upon wells, the water table of which is dropping, and will require new storage. In the southern part of the basin there is a shortage of water to meet the demand for domestic, industrial, and irrigation supplies.

Fires in the chaparral, brush, and forest cover in these drainages are sometimes disastrous. A record fire that occurred during the fall of 1932, resulting from carelessness of a recreationist, consumed the forest cover on more than 200,000 acres in the southern part. The inevitable silting from erosion of fire-devastated slopes will seriously threaten the permanency of the Santa Barbara and Montecito reservoirs. The seriousness of this prospect is suggested by the silting of the Gibralter Reservoir of the city of Santa Barbara that has followed fires.

In 1923 and 1925 fires destroyed the brush and small-tree cover on 40,000 acres, or 30 percent, of the 133,000-acre drainage basin of this reservoir. By 1928, sediment washed into the reservoir by erosion from the burned area amounted to 6 percent of the reservoir's storage capacity, and large quantities of sand, gravel, and boulders were piled along the streams in position to be washed down in future years. In 1932, silt deposits occupied more than 14 percent of the reservoir's original capacity. Since construction of the reservoir cost $57.50 per acre-foot of storage space, these erosion deposits have cost the city $120,750 in the 10 years since completion of the project. The loss of investment in storage in the Gibralter Reservoir, in 10 years, has been more than $3 for every acre burned. Silting from a drainage densely covered by brush is comparatively slight. The entire forested area in this basin has been classed as having a major watershed-protection influence.

DESERT BASIN

Of outstanding importance in the desert basin, which includes much of the southeastern part of California, is the maintenance of as effective a cover as possible on the Owens Valley watershed, from which the city of Los Angeles obtains water. The east slope of the Sierra

Nevada is narrow and steep. Only a very small part of that watershed is covered by coniferous forest. A somewhat larger part of it is woodland. The principal forest trees, whitebark pine, Jeffrey pine, pinon, and juniper, grow in open stands and produce only small quantities of litter, and there is seldom a dense cover of undergrowth. Rainfall is light, ranging for the most part from 10 inches to 20 inches or slightly more at the higher elevations. The granitic soil is rather porous and ordinarily is not readily eroded. Because of these conditions most of the forested area has been classed as of moderate and some as of slight watershed-protective influence. The importance of the water supply, however, may justify classifying part of this area as of major influence.

The forested areas at the southern extremity of the Sierra Nevada, on the Tehachapi Mountains, and on the east slope of the southern coast mountains, chiefly woodland and brush lands, have been classed as of major watershed-protective influence. The flow of streams from these areas, such as the Mojave and Whitewater Rivers, is rather meager and flashy. The demand for water for irrigation and domestic use exceeds the surface supply. The deficit is made up by pumping water from wells.

The plant cover, naturally sparse owing to low precipitation and high evaporation, has been so depleted that the basin is exposed to a considerable danger of floods from torrential rains that occur fairly frequently. A storm of more than 7 inches near Tehachapi Pass in late September 1932, caused a flood that killed 15 people and did about $1,000,000 worth of damage to property. Flood discharges from the storm area are reported to have been estimated by engineers of the Los Angeles Flood Control organization to have varied from 2,000 to 5,000 second-feet per square mile. Where the rain was most intense, representatives of the California Forest Experiment Station found it washed away 4 to 6 inches of the poorly vegetated surface soil. No gullies were found on areas having a good plant cover.

SOUTH COAST DRAINAGES

In the south coast drainage area, which lies west of the summit of the Coast Range and extends from near Santa Barbara to the Mexican border, the water-supply problem is one of the greatest in the United States. Projects planned or actually under way to provide additional supplies for the part of the basin around Los Angeles, as reported in South Coastal Basin, Bulletin No. 32 of the California State Division of Water Resources, will cost in the aggregate close to $350,000,000, exclusive of distribution systems. That report states that in the drainages of the Los Angeles, San Gabriel, and Santa Ana Rivers there are—

> * * * 57 incorporated cities, numerous urban communities not incorporated and 2,200 square miles of irrigable land or land suitable for residential development. About 2,500,000 people, or nearly 50 percent of the population of the State, live in this basin, although the area is less than 1$\frac{4}{10}$ percent of the total area of the State and only seven tenths of 1 percent of the water supply is found here. Population and irrigated area are rapidly increasing.
>
> * * * From this it may be inferred that water supply will be the limiting factor in development of the section. It is isolated and remote from other sources and to bring water to it is an engineering undertaking of the first magnitude. To amplify the local supply, the city of Los Angeles has constructed its 250-mile aqueduct to bring in Owens Valley water from the north and now proposes to extend this to Mono Basin still farther north in order to reach additional supplies.

> The metropolitan water district is actively proceeding with its Colorado River project to bring in 1,500 second-feet. [Through an aqueduct more than 200 miles long] * * *.
>
> If importations for Los Angeles City from Owens Valley be neglected, about 90 percent of all water supplies are derived from underground reservoirs underlying the valley floors on which the major part of the cities and towns and agriculture have been developed. These underground reservoirs or basins in turn get their supply by retaining a part of the wild and sudden floods of the region and a part of the rainfall which comes upon the valley floors overlying them. They regulate by natural processes the surplus waters of the wet for use in the dry years and have made the present economic development of the region possible. All plans for additional water supply propose further utilization of the underground reservoirs and control, insofar as possible, of the supplies placed in them.
>
> * * * The water plane in practically all of these has been falling for many years past. Into some, salt water is penetrating from the ocean. Water is being pumped from below sea level in 162 square miles of the Coastal Plain, according to recent surveys. * * *

The run-off that supplies these underground reservoirs comes principally from the forest and brush covered slopes of the mountains on which annual precipitation averages about 23 inches. Coniferous forest occupies less than 5 percent of the south coast drainage area, occurring principally on the higher mountain slopes and plateaus. Practically all the steep mountain slopes are covered by chaparral, brush, or woodland, which together occupy more than 40 percent of the 11,075 square miles included in the drainages, ordinarily in a dense stand that forms a complete canopy. All the lands having such cover are classed as exerting a major watershed-protection influence.

In these drainages there are two types of vegetative cover: Dense chaparral on the slopes, and hardwood trees along stream channels. In experiments carried on by the California Forest Experiment Station, surface run-off from slopes recently burned has amounted to only 1 or 2 percent of the season's precipitation of 20 to 30 inches. Even this small surface run-off is from 2 to 30 times that from adjacent brush-covered slopes. They showed also that on a level bare surface with no run-off 60 percent of a 23-inch seasonal precipitation was evaporated, leaving about 40 percent to become a part of underground supplies. In contrast with this, an average of only 30 percent of the seasonal precipitation was evaporated from soil covered with forest litter from which no surface run-off occurred. Shrub growth and litter on slopes prevent abnormal erosion, which would otherwise become destructive. The annual run-off in streams from chaparral-covered watersheds, which stream-flow records indicate amounts on the average to from about 10 to 20 percent of the annual precipitation, in large part reaches the streams by underground seepage from slopes. In the long, dry summer period run-off is normally low, and in many streams surface flow sometimes ceases entirely.

Canyon-bottom vegetation of alders, willow, and such water-loving species, transpires very large quantities of water back into the atmosphere, and by that much reduces the surface and subsurface stream flow from the watershed, during periods of highest demand for water in the valleys. In the south coast drainages this canyon-bottom vegetation occupies not more than 5 percent of the total area, but loss of water through transpiration during long dry summers by this subirrigated vegetation is relatively very large. Much water that would otherwise be lost in transpiration in mountain canyons can be saved by piping the water through the canyons past the stream-side vegetation.

Fire danger is extreme on the steep mountain slopes. In summer the chaparral becomes almost tinder dry and fires run rapidly, as much as 12 miles in an hour, and are difficult to control. Summer fires ordinarily consume the chaparral cover entirely, leaving the steep slopes bare and exposed to rapid run-off and abnormal erosion. As previously mentioned, in experiments conducted by the California Forest Experiment Station surface run-off from soils burned clean of vegetation and litter exceeded that from similar soils with a litter cover in ratios up to 66 to 1. Erosion was about 400 times as great on the denuded soils.

The results of these studies partially explain the heavy run-off from recently burned canyons in southern California which valley residents often attribute to "cloudbursts." The Burbank flood of 1928, for example, followed a fire of 1927 which burned over 704 acres of the watershed above this town. With only 1.07 inches of rain in 3 hours, but with a maximum intensity of 1.70 inches per hour for about 10 minutes, surface run-off was three times as great as on adjacent unburned canyons. Between 25,000 and 50,000 cubic yards of eroded material was swept off the burned watershed, while no noticeable erosion took place on adjacent unburned canyons.

Chief Engineer E. C. Eaton of the Los Angeles County Flood Control District is quoted in the bulletin Forestry in the State-Wide Water Plan as follows:

> Intense rains falling on a brush-covered watershed washed down only 400 cubic yards of debris per square mile, while the corresponding amount on adjacent burned-over areas rose to 12,000 cubic yards.
>
> Even with the controlling influence of 300 check dams per square mile on the burned area, the detrital material still amounted to 7,000 cubic yards. It is further important to note that the brush cover not only proved to be a strong check on the debris movement, but that it also effectually functioned in reducing the surface run-off. With 1.36 inches of rain per hour the burned-over area gave 1.01 inches in surface run-off while the area covered with brush produced only 0.42 inches. It follows that on the burned-off area only 0.35 inches of water were available for percolation * * * in contrast to 0.94 inches of water on the unburned area.

Such erosion debris rapidly impairs the permanency of flood-control and other reservoirs. Eaton, in discussing the Los Angeles flood-control district in the bulletin South Coastal Basin, points out that mountain fault lines limit the number of available reservoir sites and that construction on these sites would be costly.

While expenditures for fire control are heavy, practically nothing is being spent for restoration of cover. Intensive studies are warranted to determine economical means of rapidly reestablishing a vegetative cover and possibilities of replacing some of the highly inflammable species of chaparral with species more resistant to fire. The California Forest Experiment Station has made an important start in studying methods of revegetating the great cuts and fills of mountain highways in southern California. Autumn sowing of winter wheat and of seed of sunflower and native shrubs in contour furrows reinforced by cuttings of willows and elder, although rather costly, has proved very effective. This mixed vegetation, developing rapidly, maintained the treated slopes practically intact, while adjacent untreated slopes gullied at the rate of 800 cubic yards per acre during one winter and required heavy filling to restore them to safe grade.

CLASSIFICATION OF FOREST AREAS ACCORDING TO INFLUENCE

Of the 29,780,000 acres of forested land within the California drainages, about 21,056,000 acres has been classified as of major influence in protecting watersheds, that is, in regulating run-off or reducing soil erosion, or both. As pointed out in the foregoing, this acreage of major influence occurs chiefly in the foothill and mountain areas of the Sierra Nevada and along the Coast Range. The mixed conifer, woodland, and brush cover of the Sierra Nevada and its higher foothills, the redwood and Douglas-fir mixtures and dense brush types of the north Coast Range (with the exception of a narrow strip near the coast north of San Francisco Bay), and the redwood, Douglas fir, and other conifer cover and dense brush of the central Coast Range, all are considered to exert a major watershed-protection influence. All the forests of southern California, being chiefly chaparral and woodland on the lower slopes and mixed conifers (Jeffrey pine, sugar pine, Coulter pine, white fir, incense cedar, juniper, and piñon) on limited areas at elevations greater than 4,000 or 5,000 feet, have likewise been classed as of major influence. These forests differ widely in respect to rainfall, vegetative composition, soil, and underlying geological structure.

Approximately 3,736,000 acres of forest area has been classified as of moderate watershed-protective influence. This includes the narrow strip of whitebark pine and Jeffrey pine forest and piñon-juniper woodland on the abrupt east slope of the Sierra Nevada facing Owens Valley. It is classed as of moderate rather than major influence chiefly because of the scantiness of the rainfall and the porous nature of the granitic soil. The other large area of moderate influence is that along the coast north of San Francisco Bay occupied by dense stands of redwood and Douglas fir. On this area the forest effectively protects the soil against erosion and has a material influence in retarding the run-off of the heavy precipitation. After logging or burning, forest cover is rapidly reestablished. Erosion damage is ordinarily very much localized, and high water is seldom serious. Furthermore, the water supply is adequate to meet all demands.

Approximately 4,988,000 acres in the northern part of California and in the adjacent part of Oregon included within the California drainages has been classed as of slight watershed-protective influence. This large area of forest is made up chiefly of ponderosa pine, white fir, and other coniferous species growing upon volcanic hills and ancient lava flows. Here the precipitation percolates so promptly through the porous soil and lava into underground channels that very little surface run-off occurs and abnormal erosion is almost negligible. Such rivers as the McCloud and other tributaries of the Pitt River are fed by large springs, which are in fact a bursting forth of underground streams of considerable size.

WATERSHED-PROTECTION REQUIREMENTS AND HOW THEY ARE BEING MET

The principal factors modifying or disturbing watershed-protective forest cover within the California drainages are fire, grazing, and lumbering. The State watershed committee in its report Forestry in the State-wide Water Plan pointed out that—

> hot, dry summers favor intense and widespread burns which leave watershed surfaces bare and ash-covered, exposed to the full effects of the wash of torrential fall and winter rains.

During the 3-year period 1928–30, inclusive, 7,957 forest and brush fires occurred in California and burned 2,193,114 acres, the committee states, adding "Unfortunately these fires are, in the main, set by owners of land and local residents * * *." Another serious source of fires has been carelessness on the part of some of the recreationists who visit California's forests by the millions every year.

While most of the fires occur on foothill woodland and brush areas, large areas of virgin forest and of cut-over land are still burned every year. Fire protection is improving both on Federal lands and on private lands protected by the State. Climatic difficulties, however, require intensification of suppression activities by the Federal Government on the national forests, national parks, and Indian reservations and by the State on State and private lands. The State division of forestry is charged with the duty of protecting private lands from fire. As stated by the honorary watershed committee:

> * * * With meager funds and, frequently, lukewarm public support, it has attempted to meet its obligations through educational means, endeavoring to create popular sentiment for the prevention and control of fires. By slow stages, it is developing a machinery for fire protection covering the territory outside the national forests. It must be noted that the owners of forest and woodlands under State protection often are interested in other than the water crop of which they themselves are not the direct beneficiaries. Under these conditions, frequently the type of occupancy and use seriously impair the watershed values. This conflict in use and values must be weighed and judged in the light of the relative need for timber, forage, recreation, and water crop. Under sound forest management, such conflicts will be avoided and all of the inherent values of forest lands safely and wisely utilized. Larger State expenditures will be needed in order to carry out an adequate protection program.

Excessive use of range feed once was common over a large part of California's forested areas. Grazing has been practically eliminated from the steep brush-covered slopes within the national forests of the south and central coastal basins. Efforts have been made, also, to adjust grazing to the quantity of feed available on all national forest lands within the California drainages that are still open to grazing. With long dry summers, however, restoration of depleted cover has been slow. On private forest lands, particularly in the foothills, heavy grazing use and the common practice of burning with a view to opening up brushy areas or improving the forage have seriously impaired the watershed values of extensive areas.

In the past destructive logging and the broadcast burning accompanying it were a menace to watershed values. Broadcast burning following logging has been practically abandoned, and logging practices have been made less destructive by substituting tractor logging for high-lead skidding with heavy machinery. As a result timber stands are being left in better condition for protection of watershed values.

The national forests of the California drainages contain 13 million acres of forest land, approximately one third of the total forest area in these drainages. Watershed protection has been given careful attention in national-forest administration. In the management of timber and range numerous curtailments of use have been made in order to safeguard water resources more fully. Enough trees are left in logging to afford satisfactory reforestation and to safeguard watershed values. The subordinate vegetation in the forest is in general improving under grazing regulation. Further strengthening of the fire-control program will be necessary. Within the national parks, grazing and timber cutting are not permitted and a satisfactory watershed cover is being maintained except as it is depleted by fire.

On the 966,000 acres of forest land within the unappropriated public domain, conditions are far from satisfactory. Much of the herbaceous and shrubby vegetation is heavily grazed. Fires are set on these lands just as on private lands, exposing the soils to erosion. This area should be given a status that will insure proper management.

The situation on private lands, especially in the foothills is such that the public should acquire about 10,000,000 acres in these drainages, 5,000,000 acres of which is in commercial timber types and 5,000,000 acres in noncommercial forest types in the foothills.

Approximately 75,000 acres of land in critical condition should be planted to trees and another 100,000 acres seeded to herbaceous plants in order to more effectively safeguard watershed values. If practical methods can be developed for planting trees or shrubs on the depleted foothill areas the reforestation program should be greatly expanded.

COLORADO RIVER BASIN

The outstanding watershed problems of the Colorado River basin are (1) supplying adequate water for irrigation, power, and domestic use, (2) controlling erosion, and (3) reducing damage from local floods. As is shown by figure 12, the basin includes portions of California, Nevada, Arizona, New Mexico, Utah, Colorado, and Wyoming. The perennial flow of the Colorado River and its main tributaries originates almost entirely on the higher mountain areas, nearly all of which are forested or above timber line. Most of the sediment carried by the main river and its tributaries comes from erosion of the lands at the lower elevations, which are largely nonforested, or from the scouring out of channels. Large areas of forested land, also, have soils that are readily eroded if the protecting vegetative cover becomes depleted. The intensity of the scouring of channels is greatly increased by the soil and other erosion debris washed from slopes. Local destructive floods most commonly originate at medium or low elevations, often on depleted forest areas.

EXTENT AND WATERSHED-PROTECTION VALUE OF FORESTS

Of the 242,000 square miles of the Colorado River Basin within the United States about 70,422 square miles (45,070,000 acres), or nearly 29 percent, is forest land. Approximately one fourth of this is occupied by coniferous forests, largley commercial timber, made up principally of rather dense stands of spruce, white fir, or lodgepole pine at the higher elevations and of more open stands of ponderosa pine or Douglas fir, with an understory of herbs and shrubs, at intermediate elevations.

The aspen-brush type, predominantly aspen, occupies about one tenth of the forest area. In this type undergrowth normally is fairly dense, and small intermingled areas of brush and grassland occur.

The mountain brushland type, prevailing mainly on slopes at elevations below those supporting good stands of ponderosa pine, covers more than one fifth of the forest area. In this type oak brush is the most common species.

Practically throughout the basin, the coniferous, aspen-brush, and mountain brushland types have been classed as of major watershed protective influence. By retarding snow melt, and by facilitating the absorption of snow and rain water into the soil, they reduce the crests of floods resulting from snow run-off, aid in maintaining a sustained flow of water in springs and streams, and protect the soil against abnormal erosion. These functions are especially important on steep, rugged mountain slopes having a normally scant soil layer or soils of sedimentary origin and having an average annual precipitation of about 20 inches to 35 inches or more, much of which comes as winter snow and tends to run off rapidly in the spring unless the slopes are well protected with vegetation. Where these forest types occur on undulating or level plateau areas from which run-off normally is not rapid and on soils derived from lava or basalt that

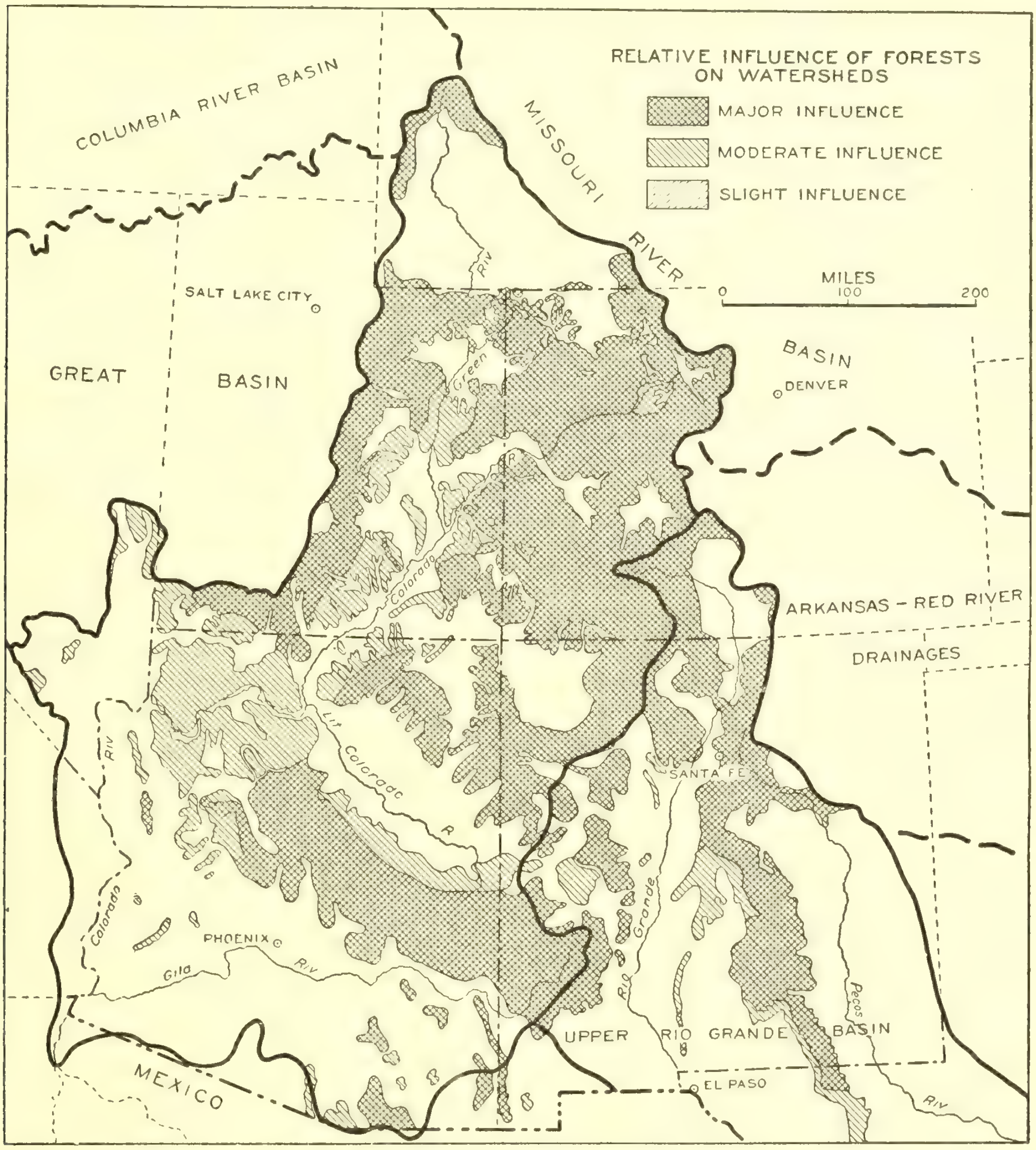
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
MILES
0
100
200
COLUMBIA RIVER BASIN
MISSOURI RIVER BASIN
SALT LAKE CITY
GREAT BASIN
DENVER
Green Riv
Colorado
ARKANSAS - RED RIVER DRAINAGES
SANTA FE
Lit Colorado R
Riv
Colorado
PHOENIX
Gila Riv
Rio Grande
Pecos Riv
UPPER RIO GRANDE BASIN
EL PASO
MEXICO

FIGURE 12.—Colorado River Basin and portion of upper Rio Grande Basin.

are not readily eroded, they are considered to exert a moderate watershed protective influence. A level forested area of porous volcanic soil about 45,000 acres in extent on the Colorado Plateau of northern Arizona is classed as having practically no watershed-protection value.

The pinon-juniper woodland, occupying about half the forest area, occurs principally near the lower limits of forest growth. The quantity of usable water obtained from this type is small. At these levels snow seldom accumulates. Most of the summer rains are so mild that there is little surface run-off from them and their effect on the water supply is negligible. Semitorrential rains are rather common and sometimes reach the proportions of "cloudbursts." Such storms cause very rapid run-off accompanied by severe erosion especially on steep and unstable slopes that are inadequately protected by a plant cover. In the woodland type there is normally but little undercover on slopes and the tree cover itself is seldom dense enough to form a closed canopy and heavy litter. This cover, such as it is, should be maintained and improved where it is depleted. As previously mentioned, studies by the Southwestern Forest and Range Experiment Station have indicated that on most of the soils on which the woodland type occurs in Arizona, which are fairly representative of woodland soils throughout the basin, a stand of herbaceous and shrubby vegetation can be maintained which with the trees is sufficient to check run-off and abnormal erosion. Growth conditions are so severe that the protecting cover can easily be seriously depleted by overgrazing, fire, or too heavy cutting.

Woodland areas have been classed as of major watershed-protection influence if their potential forest cover would aid materially in checking run-off and erosion on slopes, a heavily silt-laden run-off from which is resulting, or would result in undue damage to irrigation developments or other property. Woodland areas the topography of which is level, rolling, or moderate, and the soil of which is not readily eroded, have been classed as of moderate watershed-protection value.

Of the total forested area within the Colorado River Basin approximately 36,196,000 acres has been classed as of major watershed-protection influence, 8,829,000 acres as of moderate influence, and 45,000 acres as of scant influence.

WATER SUPPLY FOR AGRICULTURE, POWER, AND DOMESTIC USE

In the Colorado River Basin agriculture, the most important industry, is almost wholly dependent upon irrigation. More than 2,700,000 acres of land is already under irrigation from Colorado River water. Rural homes and villages dot the irrigated valleys, and large urban centers have gained added impetus in growth from irrigation farming. The irrigated portion of the Salt River Valley, for example, contains one fifth the population of Arizona. In the irrigated Imperial Valley of southern California unusually large values are present, and in the upper portion of the Colorado River Basin valley after valley owes its present development to irrigation. The United States Bureau of Reclamation has estimated[69] that the irrigated area within this basin could be expanded to 6,930,000 acres. The future prosperity of the basin depends in large part upon safeguarding the irrigation-water supply and the storage reservoirs. While the main irrigation projects have developed large storage facilities, the small enterprises in the mountain valleys have only slight storage facilities or none; hence their effectiveness depends upon sustained stream flow throughout the irrigating season.

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[69] S.Doc. 142, 67th Cong., 2d sess., 1922.

Numerous power plants and many communities throughout the basin are dependent upon sustained stream flow to meet their water needs. Of outstanding importance to the future of southern California is the Hoover Dam project. This stupendous project with its 700-foot dam will impound 30,500,000 acre-feet of water, irrigate more than 2,000,000 acres, develop more than $6,500,000 worth of power annually, and furnish the supplementary water supply needed for Los Angeles, San Diego, and other southern California cities and communities.

The flow of the Green River and its tributaries in Colorado, Wyoming, and Utah illustrates rather clearly the fact that the perennial flow for sustaining irrigation, power, and domestic supplies, comes principally from the higher mountain areas. On that watershed about 60 percent of the 18 to 30 inch yearly precipitation comes as snow, which above 7,000 or 8,000 feet elevation accumulates from October until mid-April. During the late spring months heavy surface run-off from this melting snow swells the streams to a normal high-water stage. Stream-gage records of the United States Geological Survey show that 74 percent of the annual run-off occurs in the 4-month period April to July. The low-water stage is maintained rather uniformly through the remainder of the year by the flow of hundreds of springs scattered throughout the higher mountain areas and by that of many mountain lakes. Summer rainfall at any elevation, and snowfall and springs at low elevations, make only a relatively small contribution to stream flow. The snowfall at high elevations and the conditions under which its transformation into water takes place are the important factors in water production.

EROSION

In the Colorado River Basin abnormal erosion, since white settlement has removed from 1 to 7 inches of the fertile topsoil from extensive slope and even plateau areas, is still occurring on far too high a percentage of the forest land, and is cutting out valuable alluvial soil along nearly all water courses below the dense timber belt.

The most serious erosion conditions on forest lands are found in the piñon-juniper, ponderosa pine, and mountain-brush types, especially on the heavy clay or adobe soils and sometimes on sandy loams. These soils are ordinarily deficient in humus, are more or less alkaline, do not readily absorb water, support only a thin stand of vegetation, and readily disintegrate when thoroughly wet. Thus under the influence of semitorrential rains, if inadequately protected by vegetation, they are eroded at a rapid rate. The serious effect of vegetative depletion is exemplified by the extensive areas (largely privately owned) in the pine forests near Pagosa Springs, Colo., that were logged beginning in the nineties and continuing until about 1920. The timber was heavily cut and the areas have been overgrazed, mainly by sheep. Throughout these areas there is excessive sheet and gully erosion, in practically all stages of intensity and activity.

Erosion has greatly increased in practically all the tributary watersheds since settlement. Much of the piñon-juniper type is still in the unreserved public domain, open to unregulated grazing use. Wherever water is available for livestock this land is invariably overgrazed and badly abused; furthermore, cutting and fires are widespread. Vegetative depletion has accentuated the erosion and, if we may judge from C. K. Cooperrider's studies of the Southwestern Forest and Range Experiment Station in the woodland and brush types of Arizona, the loss of soil productivity through erosion, in turn, has made maintenance of even the reduced vegetation more difficult. Thus is established a trend toward destruction that is difficult to check.

In the Verde River Valley near Jerome, Ariz., smelter fumes have killed tree growth on a considerable area. Where the grass and other vegetation, as well as the trees, have been practically eliminated erosion has become extremely serious. Over most of the affected zone, however, the soil is still protected by a good growth of grass.

At the higher elevations the soils are gravelly loams, sandy loams, or sandy silt loams. They are fertile, dark, and high in organic content. Typically they are rather thinly deposited on steep slopes, but they attain a fair depth in depressions. They support abundant forest cover and are relatively free from erosion where the cover is not depleted, although they receive the greatest precipitation occurring in the basin. Even heavy clay soils under the more humid conditions at the higher elevations produce fairly abundant plant cover which affords them good protection, although these soils erode readily when the vegetation is depleted or on areas where they have never reached stability.

According to an extensive erosion survey made by the Forest Service on the Colorado River watershed above Grand Junction, Colo., areas of heavy erosion compose 33 percent of the watershed, areas of moderate erosion 27 percent, and areas of little or no erosion 40 percent. As a general rule the heaviest erosion occurs in the nonforest types or in piñon-juniper woodland. Moderate erosion occurs in piñon-juniper, brushland, and nonforest types where cover has been somewhat depleted. Little or no erosion occurs on well-forested areas or on non-forested areas where a good vegetational mantle is maintained.

One of the most serious effects of erosion is the silting which threatens to shorten the usefulness of reservoirs. The Roosevelt Reservoir on the Salt River of Arizona already has great silt banks in its head. Portions of these are cut away and the material washed closer to the dam by each big flood; then, as the lake refills, new deposits are added. Such silt is made up of material cut from watercourses and soil from slopes where the vegetative cover has become depleted. According to settlers, serious destruction of the vegetative cover was general 30 to 40 years ago. With drought conditions prevailing during many of the last 15 years, the slopes are but slowly revegetating.

Fortier and Blaney estimate[70] that the Colorado River carries 137,000 acre-feet of silt annually past the Hoover Dam site. If this continues the reservoir will fill with silt in about 220 years, and its value for storage of flood water for use in extended drought periods will be greatly impaired much sooner. Losses of investment in engineering works from silting may be liquidated to the satisfaction of financial interests and additional dams may be built to suffer a similar fate, but the consequent decay of communities dependent upon irrigation cannot be so liquidated.

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[70] Fortier, Samuel, and Blaney, Harry F. "Silt in the Colorado River and its Relation to Irrigation." U.S. Dept. of Agri. Tech. Bul. 67, 1928.

FLOODS

Closely related to rapid run-off from slopes depleted of vegetation and to abnormal erosion are destructive summer floods. In the Colorado River Basin such floods occur, often in intermittent stream courses, mainly as a result of heavy rains. High water results normally each spring from snow melt, sometimes assuming destructive proportions in the lower reaches of the river and in its main tributaries. Those spring flows seldom become destructive in the smaller tributaries except in the occasional year when heavy warm rains produce unusually rapid snow melt. The destructive flash floods which follow semitorrential summer storms originate in greatest number and greatest intensity in the piñon-juniper and mountain-brush types and on nonforested areas at lower and intermediate elevations where the vegetation is thin. In 1921, for example, severe floods largely from such types occurred in the Dolores River, Henson Creek, Lake Fork, and East and West Rifle Creeks of Colorado following a 4-day rainy period with a maximum precipitation at Ashcroft, near Aspen, Colo., of 2.5 inches. The Dolores River washed out many miles of railroad track, and Henson Creek caused considerable property loss at Lake City by cutting a new channel through part of the town.

Price River has had numerous floods originating on the higher mountain forested areas. In 1927, for example, floods transporting immense amounts of debris and silt damaged railroad and mine property, highways, bridges, irrigation works, city water supply, and farm crops to the extent of at least $500,000. The watersheds of Gordon Creek and Willow Creek, the two tributaries which contributed most of the flood waters, had suffered a heavy reduction in plant cover on forested areas through extreme grazing use. In contrast the drainage of Miller Creek, a nearby tributary comparable to Gordon Creek, has been protected from excessive grazing use since a time several years prior to the 1927 flood, and maintains a relatively abundant ground cover even in the nonforested portions. It shows almost no abnormal erosion or channel cutting, while Gordon Creek is newly channeled to a depth of 50 feet and a width of 100 feet.

Floods have been a source of great loss to the agricultural industry. The valley bottom lands most suitable for irrigation have been subjected to inundation and debris deposit or have been cut away by flood waters. A number of small reservoirs have been rendered useless by silting or the dams have been washed out. Silting of irrigation ditches and loss of headgates and diversion dams have occurred to some extent on every stream in the region.

Conditions on the Paria River, in southern Utah, present an outstanding example. Approximately two thirds of the Utah portion of this watershed, i.e., 11 or 12 townships, is occupied by forests, chiefly of the woodland and mountain-brush types, with ponderosa pine near the headwaters. Paria was first established in 1871; by 1884 it had grown to a community of 107 permanent residents, all living on irrigated farms along the river. Floods, beginning in 1885, have channeled the valley bottom. The shifting bed of the river is now only a sandy wash, in some places a quarter of a mile wide. At Paria there have been no permanent residents since 1925, and the land still arable does not exceed 60 acres. At Henrieville and Cannonville, two of the three remaining settlements on the river approximately one third of the land capable of cultivation in 1880 has been cut away. The third settlement, Tropic, has suffered heavy, but unestimated, losses of farming land.

Kanab Creek, near Kanab, Utah, further demonstrates the effect of floods and erosion. This stream began to erode its bed about 14 years after the settlement of Kanab in 1870. It has continued to entrench until the stream bed in places is now at the bottom of a 60-foot gully 200 to 300 feet wide. The gullying extends through the woodland, which covers rather large areas of the watershed above Kanab, to the heads of tributaries in the mountain-brush type, which now have new channels 4 to 6 feet deep. The eroded material has been carried downstream, filling the Kanab Reservoir with silt and contributing to the silt load of the Colorado River.

WATERSHED-PROTECTION REQUIREMENTS

That the accelerated erosion in southern Utah and adjacent States is not due to climatic change alone is evidenced by the fact that the channeling did not start in all valleys at the same time. In some valleys it is much more recent than in others, and a few valleys are still uneroded.

The greatest damage caused by controllable factors to plant cover as a protection for watershed values on the Colorado River has come from overgrazing, fire, and excessive timber cutting, named in the descending order of importance. Nearly all the lands of the basin have value for grazing or timber production or both and are subject in varying degrees to damage by fire. Adequate watershed protection in the basin, therefore, requires proper range and timber management and fire protection. Research results indicate the desirability of controlling grazing, timber cuttings, and fire so as to make possible the maintenance of a plant, litter, and soil cover approximately equal to that which would be brought about under complete protection from use and fire.

Especially on forest areas at lower elevations, restoration of cover is essential. Range research of the United States Forest Service indicates that where soil and moisture conditions are favorable and a seed supply of suitable native plants is present, under careful management the cover can ordinarily be restored on moderately depleted areas in from 3 to 5 years. Where soil and vegetative depletion have reached an advanced stage, artificial restoration will be necessary if a satisfactory cover is to be reestablished within a reasonable period. This would take the form of planting trees on the more favorable sites and herbaceous plants on those somewhat less favorable. On the latter sites establishment of forest trees is so uncertain and growth is usually so slow that it is difficult to establish a stand of trees sufficient in itself to afford the necessary watershed protection.

CONDITIONS ON LAND IN VARIOUS TYPES OF OWNERSHIP

In general it may be said that watershed requirements are being met reasonably well or are in process of being met on the 21,913,000 acres of forest lands in the Colorado River Basin included in national forests. Fire protection is afforded, range conditions are improving under the system of management in effect, and timber cutting is regulated. Some areas that were seriously depleted when the national forests were created are not yet in satisfactory condition to safeguard watershed values. In southern Utah, for example, where the balance between the forces that build up soil and those that tear it down is extremely delicate, many national-forest areas are still affected by abnormal erosion. Lumbering, fire, and insects have been partly responsible, but the major factor has been the extreme grazing use to which the plant cover was formerly subjected. Although forage conditions are generally better within the national forests than elsewhere in the locality, from a run-off and erosion standpoint large areas within the national forests are still in a critical condition. Likewise within the national forests in the important Salt and Gila River drainages in Arizona and New Mexico, there are areas where abnormal sheet and gully erosion have not yet been corrected. These are chiefly granitic and clay soils from which the top layer has been removed and on which, because of normally low rainfall, it is difficult to restore a satisfactory cover.

Generally, however, within the national forests of the Colorado River Basin the forest cover is in a satisfactory condition for erosion control and for water delivery. Research is justified to determine further possibilities for the discharge of water in maximum quantities, at times when it is most needed, and in a condition largely free from undue silt burden.

On the national parks in the Colorado River Basin timber cutting and the grazing of domestic livestock have been materially restricted or eliminated, which should facilitate restoration of herbaceous and shrubby vegetation within these areas and increase their protective value. On the Kaibab Plateau, however, some overgrazing of the underbrush by deer is occurring which, if continued, may adversely affect the watershed-protection values of the forest.

The seriousness of erosion within Indian reservations of the basin is emphasized by Lee Muck, Percy E. Melis, and George M. Nyce in their report to the Committee on Indian Affairs of the United States Senate entitled "An Economic Survey of the Range Resources and Grazing Activities on Indian Reservations".[71] This report reads in part as follows:

> * * * It can be said without exaggeration that the control of erosion presents a grave problem in the management of every Indian reservation in both New Mexico and Arizona. On many reservations the situation is quite acute and in every case the principal contributing factor has been overgrazing. When the soil of this territory has been laid bare by overgrazing it is peculiarly subject to erosion, and the climatic conditions, particularly the prevalence of sudden and violent summer storms, tend to further aggravate the condition. When these soil and climatic conditions are considered in connection with the excessive number of stock that have for years been grazed on these areas, the disastrous progress of erosion in this region is readily understood. * * *

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[71] Survey of Conditions of the Indians in the United States. Part 22. Hearings before a subcomittee of the Committee on Indian Affairs, of the United States Senate, 71st Cong., 2d sess., 1932.

> Owing to the stand of coniferous timber occurring on the higher elevations of this region, the severity of erosion has been considerably lessened, but it is obvious to even the lay observer that the removal of this protective forest would result in even a more serious condition than is now so prevalent on the lower slopes. * * *
>
> Severe overgrazing within the timbered areas has been observed by the foresters of the Indian Service throughout the southwest region and the destruction of young growth through the activities of hungry sheep and goats is a matter of common occurrence. The continuance of this overgrazing to this degree will eventually result in the destruction of the forest and the serious erosion of the present forested areas.

Efforts are being made to establish management that will overcome the present unsatisfactory watershed conditions on the 8,493,000 acres or so of timber, woodland, and mountain brush lands in Indian reservations in the basin.

The most serious erosion and flood situations within forested areas on the Colorado River watersheds exist on the 5,998,000 acres of forested land in the unreserved public domain. Conditions are especially bad in the piñon-juniper woodland, the principal forest type. The public domain should at once be placed under public administration. On these lands and on much of the State and private land intermingled with them, unregulated grazing has led to excessive depletion of the undergrowth. Trees and even brush have been heavily cut, especially around mining camps, and forest fires are seldom controlled. Administration of the Federal lands that will restore a satisfactory forest cover is essential.

Conditions on most private lands in the basin are little if any better than those on the public domain. Overgrazing has seriously depleted the herbaceous cover, fires ordinarily burn uncontrolled, and the cutting of trees is seldom managed with a view to regeneration of the timber cover. Rapid run-off of water and abnormal erosion accordingly are prevalent. Education of private landowners as to the effects of abuse of watersheds is badly needed. Public acquisition of about 2,800,000 acres of lands having a major influence will probably be necessary in order to restore forest cover conditions that will afford the necessary watershed protection.

Within the public forests 150,000 acres of devastated land should be reforested and artificial revegetation with soil binding grasses or shrubs is needed on 200,000 acres.

UPPER RIO GRANDE BASIN

The upper Rio Grande Basin, including the Pecos River drainage (see figs. 6 and 12) has an area of about 169,000 square miles in western Texas, New Mexico, and southern Colorado, and an area of more than 50,000 square miles in northern Mexico. Approximately 27,281 square miles (nearly 17,460,000 acres), or 16 percent of the portion of the watershed within the United States, is classed as forest land.

WATERSHED PROBLEMS

The most important watershed-protection problems in the upper Rio Grande Basin are accelerated erosion, the destructive flood menace, and the demand for adequate water for irrigation.

This basin was settled by the Spanish as early as the sixteenth century. While the settlements were mainly concentrated in the nonforested valleys some, including the capital of the territory under Mexican administration, were within the forest. There is little question that the protecting vegetation near these settlements was partly destroyed in the early nineteenth century. Destruction of vegetation sufficient to menace watershed values, however, apparently did not occur over extensive areas until sometime after the Civil War, following introduction of large herds of cattle and sheep. Mining and other settlement resulted in extensive fires and some devastation of timber stands.

Following deterioration of the grass and other protecting vegetation, rapid run-off of rainfall removed much of the surface soil over enormous areas through sheet erosion, materially reducing the productivity of the land. For example, an erosion survey of the drainage above the Elephant Butte Dam made in 1931 by C. K. Cooperrider and B. A. Hendricks of the Forest Service disclosed that 35 percent of the area is being eroded seriously, 40 percent moderately, and the remaining 25 percent slightly. While a much higher percentage of nonforested than of forested area was found to be seriously and moderately eroded, the total forest area thus affected was large.

The rapid run-off from these depleted and eroded lands has formed an extensive system of gullies, small near the upper parts of slopes but often 10 to 30 feet deep and several hundred feet wide in main stream courses. Such a system of gullies is extremely efficient in concentrating water from torrential rainfall into flood proportions. The water thus accumulated, heavily charged with soil and other debris, continually adds to its burden and its destructive power by erosion from channel banks as it flows through the alluvial valleys.

Floods and erosion combine to cause serious losses almost every year. Excessive high water resulting from melting of snow, and from torrential summer rains, cut away valley farm lands, wash out railroad and highway bridges, endanger lives, and silt up reservoirs, other irrigation works, and stream channels.

Kirk Bryan, on the basis of early records and of field surveys, has outlined[72] as follows the trends on the Rio Puerco, in New Mexico. A small channel existed before 1885. While the stream banks may have been as high as 20 to 30 feet in places, in other places they were so inconspicuous as not to be mentioned by early surveyors and explorers. The river was subject to numerous floods of short duration and to occasional floods of great magnitude which overflowed the valley floor. Beginning in the late eighties, accelerated erosion has cut an arroyo in some places nearly 50 feet deep from the mouth of the Rio Puerco almost to its head. The present channel has an average depth of 28 feet and an average width of 285 feet. The continuing erosion, deepening and widening the channel, has destroyed much farm land and caused the abandonment of six small settlements including Los Cerros, San Ignacio, and San Francisco. Silt to the amount of 9,400 acre-feet a year, on the average, has been poured from the Rio Puerco into the Rio Grande for the past 42 years.

Because of floods the railroads and the State and county highway organizations are forced to expend considerable sums for special roadbed drainage and for protection works to prevent destruction of the tracks, and to replace washed-out bridges, culverts, and parts of highways and trackage.

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[72] Bryan, Kirk. Historic Evidence on Changes in the Channel of Rio Puerco, a Tributary of the Rio Grande in New Mexico. Jour. Geology, v. 36, no. 3 : 265–282. 1928.

The 1929 floods, largely from the Rio Puerco and Rio Salado, according to the report of the New Mexico State engineer caused a loss of $950,000, excluding damage to roads and railroads. Thousands of acres of farm land were buried under an almost worthless layer of clay and sand, and the town of San Marcial was practically wiped out by flood waters and by sand deposits as deep as 7 feet.

Silt deposits resulting from erosion and floods have become so great in the Rio Grande channel near Albuquerque that work has been started on a drainage and flood-control project which the chief engineer of the conservancy project estimates will cost $10,300,000 when complete. In 17 years about 337,939 acre-feet of silt has been deposited in the Elephant Butte Reservoir, the storage basin for the Rio Grande project of New Mexico, Texas, and old Mexico, according to estimates of the United States Reclamation Service, reducing its capacity by nearly 13 percent.

Since erosion, once started, accelerates and increases cumulatively in seriousness until it is checked, it is reasonable to expect greater flood damage and greater silting in the future unless corrective action is taken.

Erosion and flood problems exist on both the forest and the range lands of the Rio Grande Basin. Although they are more serious on the range lands which make up the larger part of the basin, this report is concerned only with the situation on forest lands.

Agriculture in the Rio Grande Basin is mainly dependent upon irrigation. Irrigation developments in the small mountain valleys aggregate several hundred thousand acres. The most extensive irrigation, accompanied by important urban developments occurs along the Rio Grande and the Pecos Rivers and their main tributaries where reservoirs have been established to impound flood waters and the permanent run-off from the mountain forested areas. Existing erosion conditions threaten the permanency of irrigation agriculture.

EXISTING WATERSHED CONDITIONS BY FOREST TYPES

Erosion and rainfall run-off conditions are in general more unsatisfactory in the woodland type than in any other forest type in this basin. The woodland type, the lowest type as to elevation, consists of orchardlike, or occasionally rather dense, stands of juniper, pinon, and oak with an understory of grasses, other herbs, and brush. Originally such vegetation and the litter accompanying it covered up to 50 percent, or occasionally more, of the soil surface. In open stands of this type the litter cover is ordinarily slight and the understory vegetation is an important supplement to the trees in watershed protection. Studies made by C. K. Cooperrider of the Southwestern Forest and Range Experiment Station in Arizona, the semiarid climate of which is comparable to that of the Rio Grande Basin, have shown that the herbaceous vegetation of the woodland type varies in quantity as between years of high rainfall and years of drought, but that a vigorous vegetative stand covering as much as 35 percent of the soil surface usually prevents excessive run-off and protects the soil against abnormal erosion. With annual rainfall averaging only 14 to 20 inches, normally dry springs, extreme droughts sometimes lasting several years, high evaporation, and soils which lose fertility readily through their tendency to be eroded easily, nature's balance for maintaining he plant cover is delicate.

Over extensive woodland areas the loss in plant cover has averaged one half to three quarters, as shown by the erosion survey of the watershed above Elephant Butte Dam. Such destruction is largely the result of overgrazing since the drainage was settled by whites, although locally, extreme changes have resulted from timber cutting. In some instances an increase in tree reproduction has failed to offset declines in grasses and weeds. Sheet erosion is widespread, and wherever this has reached an advanced stage gullying also is severe. Rapid soil wastage is attested by remains of grass clumps, sagebrush, and tree reproduction on soil pedestals often a foot or more in height, exposure of large tree roots, and the formation of straight-sided gullies even on slopes of low gradient. The loss of fertile top soil and of its moisture-holding capacity has intensified the deficiency of soil moisture, which at best severely limits the density of vegetation.

Such conditions prevail on most of the woodland areas in the unreserved public domain and on far too many private holdings, including many of the large Spanish land grants. On the national forests, efforts to improve conditions through regulating grazing and timber cutting have been in progress for 20 to 25 years; on many of the woodland areas, however, destruction of vegetation and soil had reached such a serious degree, particularly on readily erosible clay soils, that improvement of plant cover has been extremely slow and has not yet stopped the abnormal erosion.

Woodland areas have been classed as of major watershed-protective influence if erosion resulting from depletion of their cover would endanger irrigation or other values in valleys below. Most areas in this type where erosion would chiefly affect the productivity of the forest soil, and have little influence on other values, have been classed as of moderate watershed-protective influence.

Within the forest types above the woodland, watershed conditions are in general reasonably good. The greater part of the water supply for irrigation and for municipal use in this drainage comes from these forested mountain lands, largely as stream flow from immediate surface run-off of snow water and from springs fed by percolated snow water. The forest types which produce lumber, the ponderosa pine at intermediate elevations and the spruce at higher elevations, exert a major watershed-protective influence through retarding snow melt and run-off of snow and rain water, aiding in absorption of moisture, and protecting the soil against erosion. In the ponderosa pine type the tree stand is rather open but the litter cover and undergrowth of grasses, other herbs, and occasional shrubs, where not depleted, is normally sufficient to afford good watershed protection. In the uncut spruce forests the stand of timber is generally rather dense and, with its heavy duff, serves admirably in watershed protection. In these types lumbering, overgrazing, and fire usually decrease the watershed-protective values of the forest cover.

Most of the commercial timberland is within the national forests. Here deterioration of the protective cover has been or is being checked in most instances. Marks of past erosion still remain, but numerous eroded areas have been restored to cover conditions capable, under effective regulation, of arresting abnormal erosion. For example, on the ponderosa pine area at the head of Senorita Canyon near Cuba, N.Mex., on which as lately as 20 years ago low vegetation was rather scanty and erosion was very active, as a result of grazing regulation the slopes are now well carpeted with bunch grasses, sheet erosion is practically stopped, and the cutting in gullies is checked. Sides of gullies formerly 1 to 3 feet deep have assumed an angle of repose and the grasses that have come in on them have stabilized the soil.

On many private commercial timberlands, timber cutting and grazing have been, and are continuing to be, severe. The vast timbered area at the headwaters of the Chama River comprised by the old Tierra Amarilla Grant, for example, has been cut over within the last 40 to 50 years, and this cutting has been followed by severe grazing. As a result much of the area formerly forested is now brush land or low-density grassland. Observations by members of the Forest Service extending over the last 20 years indicate that these changes have been followed by an intensification of floods, increased bank cutting, and an increase in the silt burden of flood waters in the Chama River. Some of the once fertile irrigated farm lands on the river have become silt-sand wastes.

Interspersed with the timber types, a rather dense chaparral type occurs largely on high mountain slopes. The brush consists principally of scrub oak, New Mexican locust, and aspen, with an undercover of grasses and other herbs. This type affords a high degree of watershed protection. Fire is very injurious to it and the destructive grazing, also, has greatly impaired its protective value.

Above the commercial spruce stands is the subalpine forest type, consisting of scattered patches of spruce and fir interspersed with grassland or brush areas. Few of these small patches of timber have been depleted. With their rather dense growth, large quantity of litter, and herbaceous and shrubby vegetation they control erosion and reduce surface run-off from snow and rain to an almost negligible quantity. The grasslands intermixed with these timber clumps furnish a very effective watershed cover unless depleted. Being naturally good forage, before the creation of the national forests they were subjected to severe overgrazing which thinned the grasses and often caused them to be replaced by a scant stand of weeds of far less value in controlling run-off and erosion. The rather deep soil common on grassland areas of the subalpine type has been rather severely eroded. This erosion has not yet been entirely controlled, although on most of the eroded areas a protective grass cover is being restored. The rapid run-off made possible in part by the system of gullies in this grassland type, and the eroded material carried by this run-off, have tended to cause continuance of active cutting of stream banks in timber areas below.

Of the 17,460,000 acres of forested land in the Rio Grande Basin, 14,168,000 acres has been classified as of major influence and 3,292,000 acres as of moderate influence in watershed protection. (See figs. 6 and 12.)

LAND MANAGEMENT AS AFFECTING WATERSHED PROTECTION

Measures necessary to correct unsatisfactory erosion and run-off conditions at the source, on the slopes of the watershed, include eliminating destructive grazing and timber cutting, controlling fires, aiding restoration of suitable vegetative cover, and modifying highway construction to obviate unnecessary acceleration of run-off.

At the time when most of the national forests in the upper Rio Grande Basin were created, about 27 years ago, overgrazing and depletion of forage cover were widespread in this drainage. Destructive lumbering and fires were common, also. Although excessive erosion is not yet checked on all the 5,364,000 acres of forest lands within the national forests of the basin the vegetative stand is now declining on few national-forest areas. Not only has the regulation of grazing benefited the livestock industry by providing more adequate range feed on the greater part of the national forests, but the improvement in range conditions has materially reduced the rapidity of run-off and soil washing. Timber is now cut under regulation and fires are controlled with little loss of forest values.

On the 2,820,000 acres of forested public domain land in the upper Rio Grande Basin, the use of which is practically unregulated, cutting of trees is locally excessive, fires are often allowed to burn without efforts at control, and most of the range is still deteriorating. The public domain is often intermingled as alternate sections with railroad grant lands or with State lands or private holdings. Under such conditions it hampers attempts to control range use on these lands. It should be placed under public administration.

State lands within the national-forest boundaries are ordinarily managed under cooperative agreements which assure reasonably good fire protection and timber-sale administration. Those outside national forests are seldom so well managed. State forested lands are usually leased for grazing without any provision for maintaining the range resource or for protecting watershed values.

Cut-over lands in this basin which once had stands of saw timber offer little promise of profitable timber production in private ownership at present. Timber growth is slow, timber values are not high, and current returns from grazing or other uses will hardly pay taxes, fire-protection costs, and interest on the investment. However, uncut saw timber now privately owned will doubtless remain in private ownership until cut. In 1931 more than half the private forest land bearing stands of saw timber was protected from fire through cooperative agreements between the owners and the State or Federal Governments.

While range management adequate for satisfactory watershed protection prevails on some private forested lands, on far too many such holdings the range is in as bad a condition as on the public domain. The large values in the agricultural valleys that are endangered by these erosion conditions would warrant drastic remedial action. Private lands totaling about 5,000,000 acres showing excessive deterioration of cover on steep slopes or on soils that are readily eroded should be acquired by the public within the near future, and either totally protected from grazing or subjected only to drastically restricted grazing until a suitable plant cover has been restored.

In the vicinity of the numerous Mexican and Indian settlements both within and outside the national forests, where agriculture has been practiced for many years, erosion and floods have in many instances decreased or eliminated irrigation farming. This has resulted in increasing the intensity of other land uses such as grazing over a large area around each settlement. To permit the last vestige of plant cover to be eliminated, as is occurring about many of these settlements, means lasting destruction of watershed-protection values. How to correct this situation without destroying an already unstable economic structure is a problem demanding most intensive study and one the importance of which cannot be overemphasized.

The danger of serious erosion resulting from construction of forest roads on soils that are naturally unstable and that are readily eroded has seldom been given adequate consideration within this basin. In many instances abnormal run-off, accumulating in roads or in drainage ditches built to protect roads, has cut veritable canyons in slopes and valleys. In very few such instances has the erosion been checked. Drainage methods that will turn water from mountain roads before it has accumulated to destructive proportions, and methods of developing a cover on bare cuts and fills, deserve much greater attention.

Because channel cutting is progressing at such a rapid rate, extensive engineering works are justified as a supplement to restoration of vegetation on slopes. The cost of engineering works adequate to control the erosion would be considerable.

Definite effort should be made promptly to control erosion and rapid run-off from slopes by restoring tree growth, understory vegetation, and litter. Intensive research is justified to determine just what forest cover is most effective for each soil and forest type and what use should be permitted. Where tree growth is necessary and where devastation has reached such a point that tree growth will not come back maturally, planting is recommended where it appears practicable. This would involve about 50,000 acres. Where the herbaceous vegetation has been so destroyed under open tree stands or in openings in the forest that its restoration will be slow, artificial reseeding should be resorted to as satisfactory methods are developed. Approximately 50,000 acres would appear to justify such reseeding immediately.

GREAT BASIN

Adequate recognition has not been given to the need for watershed protection on forest lands of the Great Basin, which consists essentially of the eastward drainages of the Sierra Nevada of California, a portion of southern Oregon, most of Nevada, the western part of Utah, and small parts of southeastern Idaho and southwestern Wyoming (fig. 13). In this basin, drainage is all to the interior and, in the main, timber values are low. Here the watershed-protective function of forest lands derives its significance principally from the extreme demand for water for irrigation agriculture and for urban use, the scantiness of the water supply available, the danger of destructive silt-laden floods or even mud-rock flows from local drainage areas, and the necessity of protecting the soil against abnormal erosion and of restoring soil productivity on certain mountain lands.

DEMAND FOR WATER, AND RELATION OF FORESTS TO WATER SUPPLIES

Irrigation agriculture and its related industries are the basic permanent industries of the Great Basin, although less than 2 percent of the area is irrigated. Irrigation is the main support of most of the communities. It is essential to such leading local industries as sugar manufacturing, canning, dairying, and poultry raising, and plays a very important part in the sheep, beef-cattle, and meat-packing industries.

The great demand for water is well illustrated by conditions on the Sevier River. All the water in the channel is diverted several times for irrigation, 7 or 8 dams being used for this purpose and in part to form storage reservoirs. The return seepage from the agricultural lands below each dam supplies water for the next reservoir. In years of normal or greater precipitation all the reservoirs fill at least above the point of dangerous water shortage. In years of sparse precipitation, however, 2 or 3 of which usually occur in every decade, the lower reservoirs and some of the upper ones fail to receive enough water for more than 1 or 2 irrigations and occasionally the lowest reservoir receives none.

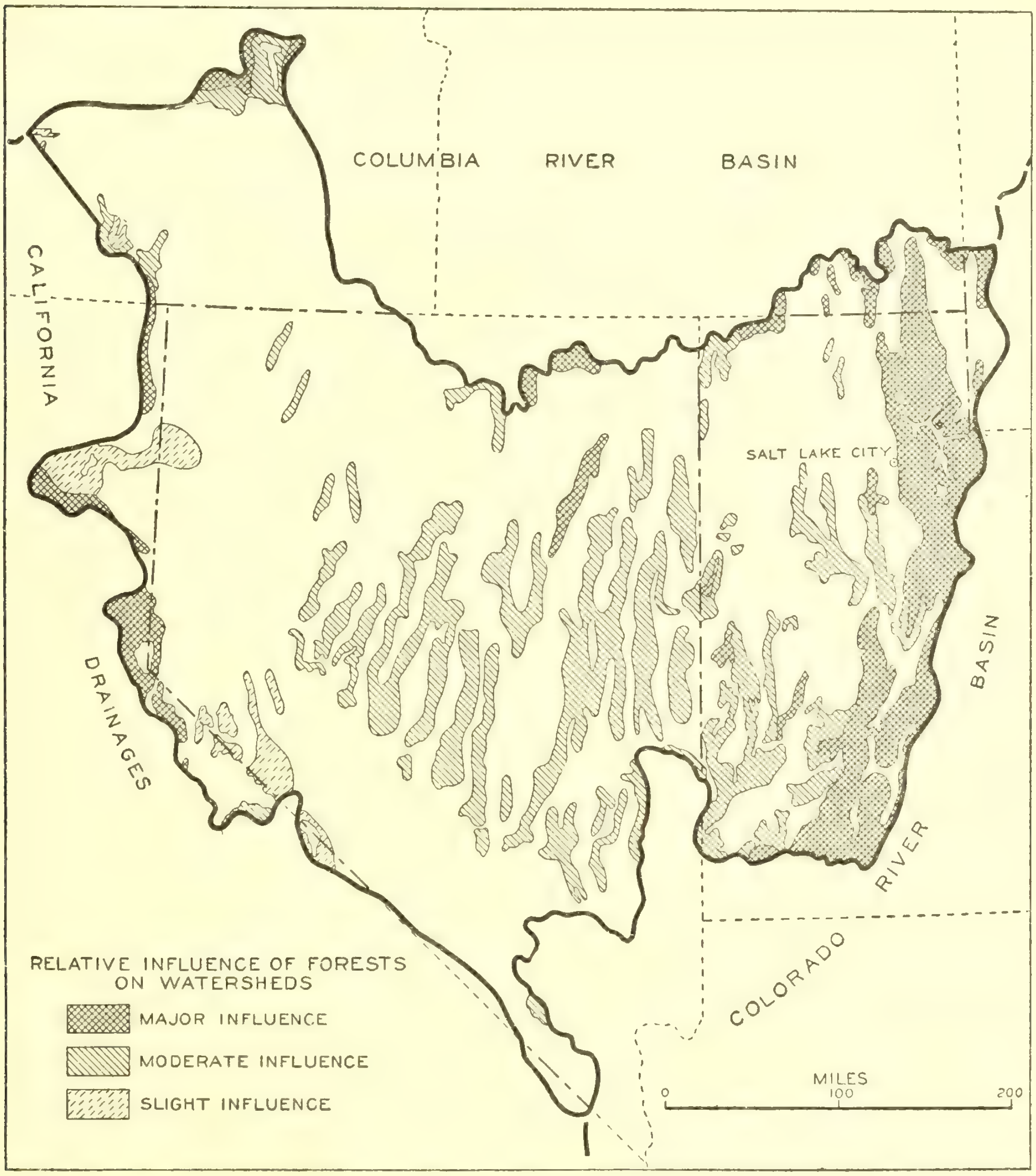
COLUMBIA RIVER BASIN
CALIFORNIA
DRAINAGES
SALT LAKE CITY
BASIN
RIVER
COLORADO
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
MILES
0
100
200

FIGURE 13.—Great Basin.

Nearly all the water for irrigation comes as run-off from forest areas. These total some 20 million acres, only 14 percent of the whole basin area. They occur mainly above 5,000 feet elevation, on mountains and plateaus. Valleys or desert basins alternate with the mountain chains. Another part of the water supply comes from large springs at lower elevations or from underground storage basins fed principally from forest-covered mountain slopes. The main irrigation developments depend upon large streams, but numerous small streams furnish the water necessary to irrigate a large number of widely scattered farms and ranches.

In the Sierra Nevada the principal coniferous timber types are the ponderosa pine at the lower elevations and a mixture of white fir, incense cedar, Douglas fir, and sugar pine at somewhat higher elevations. Still higher Jeffrey pine and western white pine come in, ultimately blending into the subalpine forest. In the eastern part of the basin the coniferous timber type is made up mainly of Douglas fir, alpine fir, and white fir, with some spruce. The aspen-fir-brush type is characterized chiefly by extensive aspen stands and by mixed stands of aspen, fir, and brush. It occurs principally in the eastern portion of the basin, on mountains and plateaus above elevations of 7,500 or 8,000 feet.

Both the coniferous and aspen-fir-brush types normally form a moderately dense cover of trees and subordinate vegetation, have a fair to good litter cover, and produce a rather deep layer of humus. Precipitation within these types is probably 20 inches or more in nearly all parts of the basin, and in some localities exceeds 40 inches. Much of this precipitation comes in the form of snow, which tends to accumulate, especially at the higher elevations. Rising temperatures in March, April, and May and occasional warm rains at that time cause rather rapid melting. The chief watershed-protective value of these types lies in maintaining a surface soil condition favorable to percolation of moisture from melting snow and rains, in retarding snow melt and surface run-off, and in checking erosion.

Water for domestic use, power, and other urban purposes, also, comes mainly from forest areas. Such important cities as Salt Lake City and Ogden, and more than 130 other communities having a population of 500 or more, obtain their supplies from these watersheds. Several rather large power developments have been installed on the main rivers to supply cities and large towns and in portions of Utah and Idaho included in this basin many towns have their own power plants on nearby streams.

FLOODS

Of almost equal importance with adequate water supply is the control of local floods, which are destructive chiefly because of the excessive load of soil and rocks which they carry. Floods of greater or less seriousness have been reported from many areas within the Great Basin in the last 30 to 50 years, especially following destruction of cover on the watersheds through the excessive grazing which came with extended white settlement and through fires and heavy timber cutting. Some of the most destructive floods have occurred in the last 10 years in the thickly populated area near Salt Lake.

Studies made by Prof. Reed W. Bailey, [73] of the Utah Agricultural College, in cooperation with the Intermountain Forest and Range Experiment Station and the Utah State Land Board, have shown that the 75-foot or deeper channel cutting and the enormous amounts of debris deposited by these recent floods were far in excess of any earlier flood action in that locality since Lake Bonneville ceased to exist some 30,000 or more years ago.

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[73] Bailey, Reed W., statement in hearings before the House Committee on the Public Lands on H.R. 11816, 72d Cong., 1st sess. 1932.

In 1923, for example, disastrous floods occurred at Farmington and Willard, Utah. Mountain sides were gullied, farm property in the valley was destroyed, and six people were killed in Farmington Canyon. The damage to town and farm property at Willard was between $75,000 and $85,000. Again, in 1930 and 1932 increasing numbers of areas in Davis, Salt Lake, and Utah Counties were flooded. Newspapers estimated the damage at more than $1,000,000. The Red Cross report on floods in these counties in 1930 states that 179,200 acres of high-priced truck and orchard land was flooded and 295 acres of such land rendered completely useless, that 134 families were left homeless. It cost Utah about $100,000 to clear the State highway.

By careful examination after the floods of 1930 the Governor's special flood commission established[73a] that the silt-laden flood water had collected chiefly on small areas of private land at the heads of the drainages where the vegetative cover had been seriously depleted or destroyed by overgrazing, by fire, and to some extent by timber cutting. This was determined by observing where gullies 10 to 20 feet deep led into the main channels. From these large gullies smaller ones radiated out into many tiny channels on almost barren spots where the surface soil had been entirely stripped away through sheet erosion. The steep slopes, at intermediate elevations, that make up the greater part of the mountain face bear a dense brush or forest cover. No gullies originated on these slopes, where the plant cover and thick litter restrained the surface flow sufficiently to permit effective penetration of water into the mellow humus-filled surface soil and prevent undue soil or water losses. The results of examinations made in 1931 and 1932, by representatives of the Utah Agricultural Experiment Station, the Utah State Land Board, and the Intermountain Forest and Range Experiment Station, of more than 15 recently flooded areas in Utah and the watersheds from which the floods came show a similar relation of cover depletion on small critical areas to rapid run-off and floods.

Paul and Baker,[74] reporting on the 1923 floods of northern Utah, attributed the floods to destruction of cover at the heads of stream courses.

That floods in the Great Basin can at least be alleviated is clearly indicated by Forest Service studies on the Manti National Forest, in central Utah. The forest and brush covered slopes and subalpine grassland openings of the Manti Canyon watershed, for example, had been badly overgrazed by cattle and sheep as early as 1890. Reynolds [75] pointed out that—

> between 1888 and 1905, the Wasatch Range, from Thistle to Salina, was a vast dust bed, grazed, trampled, and burned to the utmost.

No flood of consequence occurred in Manti Canyon before 1888, but the canyon discharged serious floods in that year and in 1889, 1893,

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[73a] "Torrential Floods in Northern Utah, 1930." Report of Special Flood Commission. Utah Agr. Expt. Sta. Circ. 92. 1931.

[74] Paul, J. H., and Baker, F. S., "The Floods of 1923 in Northern Utah." Univ. of Utah Bul. v. 15, no. 3, 1925.

[75] Reynolds, Robert V. R., "Grazing and Floods: A study of conditions in the Manti National Forest, Utah." U.S.Dept.Agr.For.Serv.Bul. 91, 1911.

1896, 1901, and 1902. Beginning in 1904 livestock were excluded from the canyon except for drift (the national forest was established in 1903). By 1909 the vegetation had materially improved. A heavy storm in August 1909 that resulted in floods from the still depleted Ephraim and Six Mile Canyons, on either side of Manti Canyon, caused little injury in Manti Canyon. On September 18 and 19, 1910, a 1.59-inch rainfall following one of 1.16-inch on September 16 in the grazed Ephraim Canyon resulted in a heavy flood. A 1.18-inch rainfall on September 18 and 19 following a 1.51-inch rainfall on September 16 in the protected Manti Canyon produced no flood. Since then destructive floods have been unknown in Manti Canyon. In recent years there has been a considerable improvement in the vegetative cover in Ephraim Canyon, and no floods of consequence have occurred.

That the restoration of herbaceous cover in large openings in the subalpine timber type contributes to the control of surface run-off and erosion from summer storms is shown by studies of the Intermountain Forest and Range Experiment Station[76] on two watershed areas of about 10 acres each in the head of Ephraim Canyon, Utah. Alpine fir, spruce, and brush occupy completely a few square rods of each area; otherwise, the cover consists of herbaceous vegetation only. In 1915, when the studies began, one area (B) was in reasonably good condition, about 40 percent of its soil surface being covered largely with perennial grasses and weeds. This cover was maintained during the study period, through careful grazing management. The thin vegetative stand, mainly of annuals, that was present on the other area (A) in 1915 occupied only about 16 percent of the soil surface. After being maintained in about that condition for 6 years the cover on this area was improved, through protection from grazing and through artificial reseeding, until about 40 per cent of the soil surface was covered, chiefly with perennial grasses and weeds.

By comparing the quantities of surface run-off and of sediment removed from the two areas during the 6-year periods 1915–20 and 1924–29, as a ratio of results on A divided by those on B, it was found that the increase in vegetative cover on area A had caused a reduction of 64 percent in surface run-off from summer rains and a reduction of 54 percent in soil material removed in erosion by summer storms. An even greater percentage reduction occurred in the difference between areas A and B in the two periods in respect to the surface run-off and sediment removed per inch of summer rainfall. The actual quantity of soil removed from area A was 133.8 cubic feet per year in the 1915–20 period and only 19.2 cubic feet per year for the 1924–29 period. This decrease is not precisely representative of the results of the increase in vegetative cover since the rainfall was lower in the latter period than in the former. Since, in the three years of record, summer storms carried off 85 percent of all the soil washed from area A annually during the period when the cover was depleted, and since summer storms are largely responsible for the destructive floods in this locality, these reductions in summer run-off and quantity of sediment carried by summer run-off indicate a definite influence of plant cover in reducing danger of destructive floods from rains on such mountain watersheds.

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[76] Forsling, C. L., "A Study of the Influence of Herbaceous Plant Cover on Surface Run-off and Soil Erosion in Relation to Grazing on the Wasatch Plateau in Utah." U.S. Dept. Agr. Tech. Bul. 220, 1931.

EROSION

As these flood situations indicate, in the Great Basin erosion of mountain and foothill slopes is intimately related to flood destructiveness. Some floods are so heavily charged with erosion debris that they become mud-rock flows. Doubtless the most serious phase of this erosion, however, is soil wastage from slopes. Close observation of soil conditions on the Wasatch Plateau in central Utah indicates that in large areas of open grassland in the forest, 6 inches or more of the fertile topsoil has been lost through sheet erosion. Observations by the Forest Service show that in the juniper-sagebrush type along the edges of the Toyabe National Forest, Nev., on private land, on the public domain, and to some extent on national-forest land, considerable areas are cut with shoestring or larger gullies, accompanied by sheet erosion. In Reese River Valley, also, there are gullies 2 or 3 feet to 8 or 10 feet deep in this type. Another area a few miles north of Elko shows considerable surface erosion and some gully erosion. On most of the forest area in the Great Basin erosion has not gone so far but that it can undoubtedly be checked by restoring the vegetative cover.

While abnormal erosion has been severe in all forest types in the Great Basin, preliminary surveys by the Forest Service show that it is most serious in the pinon-juniper type, which occupies two thirds or more of the basin. This type is largely characterized by orchard-like stands of pinon and juniper, scattered oak and other brush, and herbaceous growth. The pinon-juniper type occupies the lower, drier foothills and mountains, where the annual rainfall ordinarily totals only 12 to 16 inches, part of which may come in occasional semitorrential rains. At best the vegetation is scant and little litter accumulates. On large parts of the area, particularly in the public domain, even this scant stand has been reduced one half or more. Sheet and gully erosion occurs almost throughout the pinon-juniper type, although within the national forests the vegetative cover in this type has shown on the whole a slow but steady improvement and the excessive loss of soil is being checked.

The loss of soil productivity through erosion is shown by studies of the Intermountain Forest and Range Experiment Station of soils from openings of the subalpine timber type in Ephraim Canyon. The growth of many-flowered bromegrass and of wheatgrass was more than twice as great and that of peas more than eight times as great on noneroded as on eroded soils. Furthermore, eroded soils used 38, 23, and 80 percent more water for each pound of growth in bromegrass, wheatgrass, and peas, respectively, than did the noneroded soils.

WATERSHED-PROTECTION REQUIREMENTS

The 19½ million acres of forested land within the Great Basin has been classified according to watershed-protection influence as approximately 5½ million acres of major influence, 12 million acres of moderate influence, and 2 million acres of slight influence. (See fig. 13.) Those lands classified as of major influence are chiefly mountain forested areas, the water from which is in great demand or on which, if their cover becomes depleted, destructive floods may originate, and foothill or low mountain areas, chiefly woodland, having readily erosible soils, the erosion of which might seriously endanger irrigation or other works or add to flood destructiveness. Those areas classified as having a moderate watershed-protection influence are chiefly woodland areas from which little water normally is delivered and the erosion of which would not seriously damage lands other than the forested areas themselves. A rather large area in northeastern California supporting ponderosa pine, lodgepole pine, and woodland species has been classed as having a slight influence on watershed-protection values. Most of the area is level or of rolling topography. Its soils, derived from volcanic rocks or dust, absorb precipitation readily, and run-off and erosion are seldom serious.

By far the most important requirement for overcoming the unsatisfactory watershed-protection conditions in the Great Basin is control of grazing. Timber cutting and fires also must be controlled. On the 6,670,000 acres of forested lands within the national forests, where grazing and timber cutting are regulated and fires are held to small acreages, forest cover conditions are, in general, improving, and erosion and extremely rapid run-off are being checked.

There is nearly 9 million acres of public domain in the woodland, mountain brush, and timber types within the basin. Most of this is not now producing anywhere near the quantity of forage or protecting vegetative cover that it could produce were it placed under public administration. Conditions on private and State lands are little, if any, better. Many areas in the woodland and lower-brush types have been so badly overgrazed and burned that hardly anything is now growing on them except downy bromegrass, an annual of very low value from either a grazing or a watershed-protection standpoint. On some areas of readily erosible soils where the herbaceous vegetation has been practically destroyed it may be necessary to eliminate grazing for a time in order to restore a suitable protective covering, unless it is possible to find plants that can be established artificially on these areas. On by far the greater percentage of the basin area, however, adequate regulation of grazing will doubtless restore a satisfactory watershed-protection cover.

The State, county, or Federal Government should acquire about 1,800,000 acres of major-influence forest land, especially the critically denuded areas at the heads of canyons, now in private ownership, from which destructive floods have come. On these areas, in order to restore the forest or herbaceous cover, it will be necessary to correct present overgrazing and to seed or plant erosion-control plants. Dams in the larger gullies and terraces seeded to grasses or other plants on the steeper denuded slopes will aid in attaining control of erosion in a reasonable period. Some 50,000 acres in this basin should be planted to trees and an additional 200,000 acres reseeded to grasses or other herbaceous erosion-control plants.

COLUMBIA RIVER BASIN

The Columbia River Basin (which as here considered includes only lands east of the Cascade Divide) drains parts of Washington, Oregon, Idaho, Montana, Wyoming, Utah, and Nevada, and also a part of Canada, as is shown by figure 14. It is a region of valuable forest growth, heavy snows, rapid spring run-off, large and valuable irrigation developments, extensive power possibilities, great demands for domestic water supplies, and large areas of easily erosible soils.

FOREST TYPES AND THEIR WATERSHED-PROTECTION VALUES

Of the 204,873 square miles in the basin 92,226 square miles (approximately 59,025,000 acres), or 45 percent, is forest land, located principally in the rougher mountain country. This forest land supports some of the most valuable timber in the West.

Near the point where the Columbia River passes through the Cascade Range the Pacific Coast Douglas fir type occurs, forming a dense stand of large trees with heavy undergrowth and litter. Where uncut and unburned it serves unusually well in controlling run-off of the heavy precipitation which occurs in that part of the drainage, often totaling 80 inches a year. Chinook winds in winter sometimes cause such rapid melting of snow as to bring about floods of short duration. After fires the land is likely to reclothe quickly with a new growth of timber reproduction or of shrubs and herbaceous vegetation that is effective in preventing erosion and, at least moderately, in slowing down run-off. The Douglas fir areas have been classified as of major watershed-protection influence.

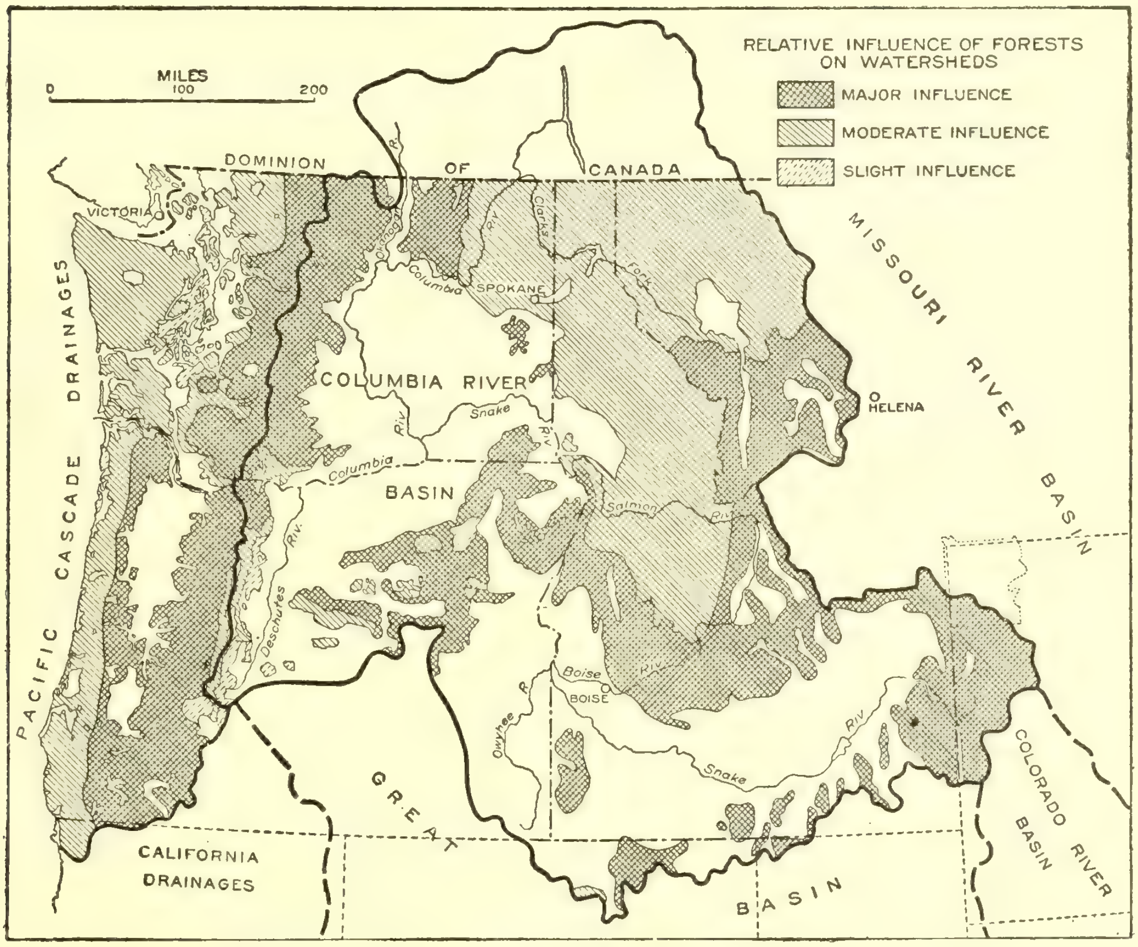
RELATIVE INFLUENCE OF FORESTS ON WATERSHEDS
MAJOR INFLUENCE
MODERATE INFLUENCE
SLIGHT INFLUENCE
MILES
0
100
200
DOMINION OF CANADA
VICTORIA
R.
Okanogan
Columbia
Riv.
Clarks
Fork
SPOKANE
MISSOURI RIVER BASIN
HELENA
COLUMBIA RIVER BASIN
Snake
Riv.
Columbia
Salmon
Riv.
Deschutes
Riv.
PACIFIC CASCADE DRAINAGES
Boise
Riv.
BOISE
Owyhee
R.
Snake
Riv.
GREAT BASIN
CALIFORNIA DRAINAGES
COLORADO RIVER BASIN

FIGURE 14.—Columbia River Basin and Pacific Cascade drainages.

On areas of lower precipitation throughout the basin, at the lower fringe of the timber, the main tree cover is scattered ponderosa pine or juniper. The trees ordinarily do not form a closed canopy. Litter is scant. Here precipitation usually averages about 15 to 25 inches a year, with a dry summer period. Run-off from these forests is not particularly large or rapid except in occasional instances when snows melt rapidly or semitorrential rains fall. In these open forest stands the principal erosion-control influence is the undergrowth of herbs and shrubs. On large areas the perennial herbaceous vegetation has been seriously depleted. Studies by the Forest Service in southern Idaho have shown that in the main these open timber stands, under satisfactory management and with a good understory of a herbaceous plants, are highly effective in controlling abnormal erosion that would otherwise become serious. Where such conditions prevail, these forests have been classified as of major watershed-protection influence. In the volcanic pumice soils, especially in central Oregon and part of eastern Washington, absorption of rain and melting snow is normally so rapid, and the danger of abnormal erosion so slight, that where these forests occur on such soils their watershed-protection influence has been classified as moderate or slight.

At intermediate elevations the forest is more dense, made up chiefly of ponderosa pine, often with an intermixture of larch or fir. The western white-pine type occurs as an unusually dense forest with a heavy litter on the better soils, especially of northern Idaho. Usually above these types but also intermixed with them in places are extensive stands of lodgepole pine. Mixed with these several types and sometimes occurring as an individual type is Douglas fir. In these types precipitation is somewhat higher than in the lower fringe types. It ranges from as low as 20 inches in the ponderosa pine type at the lower elevations to 50 inches or more at higher elevations. Summers are normally dry; much of the precipitation comes in the form of snow, which accumulates to depths of 5 or 10 feet or more. The melting of this snow causes a high spring run-off and sustains reasonably well a low summer stream flow from underground seepage. An adequate forest litter prevails which together with the timber and understory vegetation ordinarily controls erosion and regulates stream flow rather effectively.

In northern Idaho and northeastern Washington these dense forests have been classed as of moderate watershed-protective influence. In this section water yield is normally high, the demand for water is only moderate, and erosion is seldom serious, although the loess soils characteristic of the region are eroded readily if exposed. After destruction of the cover by fire a plate moss forms on the soil and holds it in place until brush, herbs, and timber reproduction reclothe the soil completely. Erosion of course can become serious if this reclothing is hindered by overgrazing.

Types in which the timber and other growth is dense have a very high watershed-protection value on the easily eroded granitic, clay, or clay-loam soils and where delivery of maximum quantities of usable water is important, as in southern Idaho. On the pumice soils of Oregon and Washington these dense forests exert a slight to moderate moisture-conserving influence through delaying snow melt and improving and protecting the soil with their litter.

In the upper reaches of Clark Fork River, in western Montana, forest types commonly in more open stands are of major watershed-protective influence. The demand for water and the need of regular stream flow are great. Erosion may become serious if fire, grazing, or some other agency thins the cover, since revegetation tends to take more time than in the more humid area on the lower reaches where the forest is classed as of moderate watershed-protection value.

Excessive run-off and erosion occur on areas around Butte and Anaconda, Mont., that have been rendered practically barren by smelter fumes. The fumes have killed tree growth over an extensive area, but on much of the affected area sufficient grass remains to retard abnormal erosion.

The subalpine forest, usually scattered growth or patchy stands of alpine fir and white-bark pine with intermingled grass or brush lands, occurs at the higher elevations, extending to timber line where winter snow depth often exceeds 10 feet. The patches of tree growth, together with good stands of herbaceous and shrubby vegetation in the openings, serve very well for erosion control and bring about a rather satisfactory delivery of the heavy snow blanket. When the herbaceous cover is broken the value of the type for erosion control ordinarily is impaired.

Brush fields, often the result of fires, are intermixed with areas of dense timber. The dense growth of brush, the understory of grasses and other herbs, and the litter formed within the brush clumps control erosion with unusual effectiveness unless the cover is depleted. Forest Service studies in southern Idaho have shown that on extremely steep brush slopes the dense vegetation and the loose soil maintained under the brush cover facilitates rapid absorption of moisture, and erosion is negligible.

WATER-SUPPLY PROBLEMS

How to obtain adequate water for irrigation on the Columbia River drainage without excessive cost for storage is a great problem, which becomes more intense when rainfall is subnormal for several years, as has recently been the case on much of the area. The large quantity and high values of the irrigated land, as well as the high average annual returns from the land, make irrigation agriculture a dominant industry. According to the 1930 census irrigated land in the basin totals 3,389,000 acres and represents an investment in lands, buildings, irrigation enterprises, and implements of several hundred million dollars.

Many large irrigation projects are found in the basin, including the Twin Falls and Boise projects of Idaho and such important apple-producing areas as the Yakima and Wenatchee of Washington and the Hood River of Oregon. Of outstanding importance is the projected Columbia Basin project of Washington, which involves irrigation of some 1,200,000 acres. Many other areas are capable of irrigation development; in southern Idaho, for example, there is more than 2,600-000 acres of irrigable land.

Water power, also, is of great importance in the Columbia River Basin. On the Snake River and its tributaries of southern Idaho, for example, 166,000 horsepower has already been developed. The Lake Chelan development alone has a present capacity of 125,000 horsepower. Smaller plants are in operation on many rivers, and the undeveloped possibilities in the basin run into several million horsepower. The domestic water supplies of numerous cities and towns, also, originate chiefly on forested watersheds of the basin.

The influence of forest cover in regulating stream flow in the Columbia River Basin is indicated by a preliminary Forest Service study in the Clearwater River drainage in northern Idaho, previously discussed. The burning of some 535,424 acres, or 17.7 percent, of the watershed in 1919 caused the following changes in stream flow in the 5 subsequent years as compared with the 5 years prior to the fire: (1) An average advance of 14 days in the date of peak flow; (2) 9.5 percent greater average flow on peak days, and nearly 36 percent greater flow in May; (3) an increase in the flow during the period April to June, inclusive, from 66 percent of the total annual flow to 73 percent; (4) a decrease in the flow during the period July to September, inclusive, from 13 percent of the yearly flow to only 9 percent; and (5) approximately 96.5 percent as much run-off from 88 percent as much precipitation. These changes are of great moment. April to June flow is, of course, chiefly the result of surface run-off from melting snow, while July to September run-off results almost entirely from the slow drainage of ground water. The effect of the fires appeared to increase the spring flood flow, and to do this largely at the expense of ground storage of water that would have fed the streams later in the year, particularly during the summer period.

EROSION

Of equal or greater importance with effective regulation of stream flow is control of erosion. A large part of the forested area of the Columbia River Basin is made up of coarse, readily erosible granitic soil. This soil is so loose that where plant cover is scarce or absent it is readily swept off in sheet erosion. Rapid run-off then forms gullies from a few inches to several feet deep. Loose soil on the edges of the gullies soon crumbles, and within a year or two after being formed many of the smaller gullies have so smoothed over as to be almost unnoticeable. Such abnormal erosion is taking place over extensive areas.

How serious such erosion is on this granitic soil is shown by a Forest Service survey of a part of the Boise River watershed in Idaho. Approximately 62 percent of an area of nearly 350,000 acres had suffered distinct sheet erosion and 10 of this 62 percent was also cut by gullies of a type not readily obliterated by creeping soil. Depletion of vegetation from past overgrazing and trampling by livestock of soils inadequately protected by vegetation are important causes of the erosion. Of the 190,991 acres in the grazed timbered area, sheet erosion had taken place on 64 percent, and on 8 of this 64 percent gully erosion also had taken place. Of nontimbered grazed areas more than 78 percent had suffered sheet erosion and 15 percent included in this had suffered gully erosion. Of the 52,817 acres of timber and brush areas where the cover was too dense or the slope too steep to permit grazing only 16 percent showed sheet erosion and but 2 of this 16 percent showed gully erosion.

In many places crowns of old grass plants are found elevated 4 to 8 inches above the surrounding surface, from which erosion has removed all fine dark soil, exposing a raw, inert stratum of unconsolidated gravelly sand that offers no real resistance to water erosion. On those areas protected by a dense cover of timber, wheatgrass, and yarrow, or of mountain brush a mellow black soil 6 to 18 inches deep still remains and soil loss through normal erosion is probably offset by soil formation.

Studies by the Intermountain Forest and Range Experiment Station in this locality showed that noneroded soils contain from 6 to 19 percent organic matter as compared with ½ to 4 percent in the raw eroded soils. The average water-holding capacity of the soils of greater humus content was 81 percent, as compared with only 44 percent for the eroded soils lacking in humus. On the latter soils there is no measurable depth of litter, whereas there is 1 to 3 inches of litter on lightly grazed noneroded soils of nontimbered areas and 1 to 6 inches on the soils of densely timbered areas.

Some rather large areas of private forest within the Columbia River basin have been heavily cut and burned, and this has caused material thinning of the timber stand and some erosion; the principal cause of erosion, however, has been the decline of the herbaceous undergrowth of the forest, largely from overgrazing but in part from fires. Bunch grasses, which in good stands effectively control erosion and build soil, have, over large areas, been almost replaced by downy brome and other inferior annuals or perennials. This replacement is especially marked on the several million acres of forest land in the public domain. Forage production on the forested public-domain areas and on intermingled private land has been found by Forest Service observers to have been reduced in many instances by from 50 to 80 percent. Such conditions are adversely affecting the livestock industry as well as the watershed-protection values of the forest.

FLOODS

Where only scant cover is present on the watersheds to interrupt run-off, the combination of semitorrential rains, rapid snow melt, and ready formation of gullies causes local floods on many of the smaller tributaries. These local floods sometimes do considerable damage, destroying improvements and depositing mudrock flows at the mouths of the drainages, sometimes destroying good agricultural land.

A cloudburst in 1932 on Loon Creek, on the Challis National Forest in Idaho, for example, caused heavy run-off to originate on a 1931 burn, resulting in a deposit of sand and debris in tributaries of the creek so heavy as to destroy fishing in parts of this stream for at least several years. A similar rain in 1932, on a 1931 burn on the watersheds of Richardson and Mann Creeks, on the Idaho National Forest, caused a heavy flood that cut deep gullies, gutted stream channels to bedrock, and swept debris down these canyons into the Salmon River. The mud flow at the mouth of Mann Creek dammed the Salmon River to a depth of 20 to 25 feet and for a length of 450 feet, causing the formation of new temporary rapids.

High water can be expected practically every spring in nearly all important tributaries of the Columbia River as a result of the melting of the large accumulations of snow in the mountains. This high water in the main streams seldom assumes the proportions of destructive floods, although usually it causes minor damage along the stream courses. It does, however, move a considerable quantity of silt which has collected in small tributaries down to the main river channels. By 1930, 15 years after the construction of the Arrowrock Dam of the Boise project, silting was estimated to have reduced the storage capacity of the reservoir by 7,000 to 8,000 acre-feet. This amount of storage space represents more than $100,000 of the original cost of the dam. Officials of the water-users' organization estimated that by 1930 the sand deposit at the power dam had reduced its capacity by 25 percent, and considerable silting of canals and other irrigation works has caused additional expense.

Another reason for preventing silting of the Columbia River is the use of the river for navigation. The value of shipping and of rafts of logs and piling moved on the Columbia River annually from 1926 to 1930 amounted to about $383,000,000.

PRESENT WATERSHED CONDITIONS ON FEDERAL AND OTHER LANDS

In the Columbia River Basin fire is by far the most damaging influence on the watershed-protection values of the forest. Summers are normally rainless, and with relative humidities often below 10 percent. Under such conditions the heavy accumulation of litter, the drying of herbaceous vegetation, and the density of the timber growth combine to make a serious fire hazard. Insect killing of such species as lodgepole pine over extensive areas has added to the depth of the litter and to the difficulty of controlling fires once they are well started.

Fires burn hundreds of thousands of acres in the Columbia River Basin nearly every year. In dry years the fire situation becomes almost catastrophic. Very drastic and energetic measures have been taken by the Forest Service to overcome the extreme natural fire hazard and reduce the national-forest area burned yearly to a point at which serious impairment of timber growth or watershed values will not be involved. In northern Idaho, for example, for watershed areas where the watershed-protection values of the forest are classed as moderate the best information available places the permissible burn at about 0.7 percent per year, or 7 percent in 10 years. Where the watershed-protection values of the forest are rated as high, the limit of annual burn should not be greater than one half of 1 percent. Even on national-forest lands, unfortunately, the average area burned during the 10-year period 1921–30 exceeded the allowable percentage, particularly in the valuable commercial timber types such as the larch-fir, western white pine, and cedar-hemlock. On the Clark Fork River drainage 24 percent of the western white pine area was burned over. If such losses continue, profitable timber growing in these valuable types will become impossible. For timber production, allowable burns in these types would normally be less than those indicated above for watershed protection. Accordingly if fires can be so far controlled as to permit profitable timber production, it is reasonable to assume, watershed-protection requirements will be met.

On private lands outside the national forests fire protection is even less satisfactory. It is probable that few private owners will attempt to carry their cut-over land until it is ready for another cut, for much of this land has already been devastated by excessive cutting and fires. As more and more private lands are cut over the incentive for fire protection becomes less. Thus it is to be expected that damage to watershed values by fire on private lands will increase unless more adequate fire protection is provided.

Large areas of cut-over land are reverting to public ownership for nonpayment of taxes. On many such areas, fire control is far from what it should be. Timber cutting is often severe, and where fire follows cutting devastation is widespread, materially influencing the watershed values. On some rather large areas still in the unreserved public domain, reburns of timberlands cut over in the early days are greatly adding to deforestation.

Present logging methods ordinarily do not seriously injure watershed values except where logging is followed by fire. On national-forest lands, cutting usually is more or less selective and leaves an understory of young trees and underbrush. On private land, also, cutting is seldom so severe at the present time as to have serious effects on watershed values except on some western white-pine areas. On certain large areas, however, for example in Idaho, the timber has been practically clear cut and burns to clear the slash have seriously delayed restocking to timber, thus materially reducing protection values.

Overgrazing is or has been an important factor in unsatisfactory watershed conservation throughout the basin. On some areas, especially in northern Idaho and western Montana, demand for grazing is so light that watershed values are not greatly endangered by grazing use. On many forest areas in southern Idaho, eastern Oregon, and central Washington, however, because of easily erosible soils, steep slopes, open tree cover, and semitorrential rains, overgrazing has created a critical erosion problem. On large private holdings grazing is usually leased without restriction on use. Because of overgrazing in the past and even at present, the vegetative cover on many private lands and on the public domain is so seriously depleted that it does not effectively protect the soil against erosion. Heavy grazing together with the trampling of livestock, especially on loose, granitic soil, tends to destroy the vegetation and litter that normally would keep the top layer of soil mellow and open.

REQUIREMENTS FOR WATERSHED PROTECTION

On the 34,755,000 acres of forest land within the national forests in the Columbia River Basin, watershed conditions are in the main rather good. Fire protection needs strengthening. Cutting is ordinarily not detrimental. Although forage conditions are improving or being maintained on most range areas, overgrazing has not been entirely corrected and some special adjustments on critical areas may yet have to be made. In general, conditions are rather good also on the 2,225,000 acres of forest land in Indian reservations.

Practically all the forest area on the public domain, amounting to about 1,776,000 acres, could justifiably be added immediately to the national forests for the purpose of watershed protection. Grazing regulation on this area should permanently benefit the livestock industry, as well as assuring more adequate protection to watershed values. Greater effort to control fire is needed. In addition, timber cutting should be regulated more strictly.

Since few counties can afford adequate forest fire protection, it seems logical that the States or the Federal Government should acquire a considerable part of the private lands that are reverting to public ownership for nonpayment of taxes, in order that the watershed and other values of these lands may be adequately safeguarded. Available data point to the need for public acquisition of about 12,400,000 acres of forested watershed lands in this basin.

On badly depleted areas efforts should be made to restore a cover that would be more profitable and that would protect the soil and water flow more effectively. The area on which forest planting will be necessary for watershed protection is roughly 150,000 acres, Many of the burns in the western white pine type, for example, should be planted with trees. About 200,000 acres of openings in the forest where the vegetation is depleted, but where moisture conditions are favorable, should be reseeded to herbaceous erosion control plants. If practical methods for artificial reseeding of the drier low-elevation forest ranges to forage plants can be developed, many of the areas, now supporting a thin cover of annual plants, should be restored to a perennial type of vegetation more typical of what they formerly produced.

Thorough research is justified to determine just what cover is most satisfactory for the different exposures, soils, and other conditions, how to restore and maintain such a cover, and what utilization if any can be permitted under various watershed conditions.

PACIFIC CASCADE DRAINAGES

The region west of the Cascade Range of Oregon and Washington (see fig. 14) is one of heavy precipitation, deep snows, and steep and rugged topography, all conducive to heavy and rapid run-off. Over most of the drainages the forest growth is dense, as a result of heavy precipitation, fertile soils, and a long growing season. The forests are predominantly Douglas fir, with western hemlock and silver fir also prominent. At the higher elevations occur mountain hemlock and alpine fir. A heavy undergrowth, principally of brush and ferns, combines with the tree growth and thick litter to form a protective cover for the slopes, which is unusually effective in conserving moisture and preventing erosion. The forest reaches elevations of 4,500 to 6,000 feet in the northern Cascades and 7,000 feet or more in the southern. At the upper elevations the forest is mainly open and is often difficult of access. Above the forest are rugged mountain ridges and numerous peaks, several with glacial fields. Of the total area of 49,450 square miles in these Pacific Cascade drainages 41,386 square miles (about 26,487,000 acres) is forested land or potential forest land now bearing a brush cover. Of this area approximately 15,564,000 acres, principally the steep slopes of the Cascade Mountains, has been classified as having a major watershed-protection influence, 9,509,000 acres, largely bordering the Pacific coast, as having a moderate influence, and 1,414,000 acres, chiefly on islands in Puget Sound, as having only slight to no influence.

Because of the extremely heavy precipitation, averaging from 50 to 75 inches and in some places totaling as much as 125 inches a year, the heavy snowfall, which at the higher elevations totals 30 to 50 feet, and the occurrence in winter of Chinook winds accompanied by warm rains, floods are inevitable. Stream channels have, in the main, adapted themselves to take care of large amounts of water. Occasionally, however, floods do considerable damage to high-value land and improvements.

Owing to the abundance of water and the great fall in streams, these drainages contain the greatest concentration of waterpower resources in the United States. About 625,000 horsepower has already been developed, at a cost of more than $65,000,000, and more than 4,500,000 horsepower remains to be developed.

A very large population draws upon the water supplies of these drainages for municipal use. Seattle, Tacoma, Portland, and practically all the smaller towns and cities obtain their water from forested watersheds. Most of these municipal watersheds are within national forests and have been set aside as special reserves on which other uses are restricted or entirely eliminated. The larger cities have developed water storage for dry periods. The pure, clear water from the heavily forested slopes is ideal for municipal use and for long life of storage reservoirs.

Within the upper Willamette, the Rogue, and other river drainages of southwestern Oregon, irrigation has made it possible to produce high-value crops such as fruits and vegetables in the rather dry interior valleys. Approximately 80,000 acres of otherwise low-value land has been placed under irrigation, and as a result a considerable number of prosperous communities and cities have been developed.

Without forest cover or other protective vegetative growth the soil over the greater portion of these drainages would erode easily; where there is a heavy forest cover, however, indications of erosion are practically lacking. Logging operations cover some 200,000 acres in these drainages each year, but because of the heaviness of the timber growth the individual logging areas are relatively small. The destructive logging methods used in the Douglas fir type, including the burning of slash following cutting, expose the soil to sheet and gully erosion. Rank herbaceous vegetation and a brush cover of sprouts quickly reclothe the soil surface and check whatever erosion has started. It is but a few years until the rapidly growing timber reproduction which comes in thickly on the exposed mineral soil following the slash burn overtops the low-growing vegetation and true forest conditions are restored. If repeated fires take place, however, the timber cover is destroyed and forested areas are transformed into brush fields, which according to Forest Service observers are less capable of retarding snow melt and of regulating stream flow from the heavy precipitation.

On the upper slopes of the Cascade Range, particularly in the northern part of the range, avalanches occur commonly. Occasionally they have been exceedingly destructive of life and property. Many of them start above timber line, on steep slopes at the heads of canyons, and follow a definite course down the canyons. Such avalanches, known as "canyon slides", occurring almost yearly, keep a "slideway" thoroughly stripped of sizeable tree growth. This type of slide must be considered the inevitable consequence of very heavy snowfall on steep, nonforested slopes.

Another type of avalanche known as "slope slide" is characteristic of hillsides that were once forested but have been devastated by fires or logging. On such hillsides great areas of wet snow sometimes start to slide, as snow does on a steep roof, carrying with them all in their path. Slides of this type do not occur until the forest has been burned or cut, because the trees pin the snow blanket to the ground, so to speak, as nails hold the shingles to a roof. Keeping the steep slopes well forested will forestall the damage which such avalanches do to all in their path and to the valleys below.

The main slopes of the Cascades are within the boundaries of national forests. The national forests of the Pacific Cascade drainages include 8,588,000 acres of forested land in Federal ownership and large acreages of private forest holdings. Of the Federal lands within the national forests, the watershed-protective influence of approximately 5,188,000 acres is classified as major and that of about 3,400,000 acres as moderate. The dry summers make tinder of dense vegetative growth, and although energetic efforts are made to protect these lands from fire extensive fires still occur. Fire-suppression efforts must be further strengthened if timber and watershed values are to be adequately safeguarded. Under proper regulation the timber, grazing, wild-life, and recreational values of these lands are used advantageously without impairing watershed values.

Private holdings compose more than half the forested area of the drainages. Of this private land, approximately 8,576,000 acres are classed as of major watershed-protective influence, 4,781,000 acres as of moderate influence, and 868,000 acres as of slight influence. The usual practice is to clear cut the timber and burn the slash. This practice is ordinarily followed by satisfactory vegetation of the area. Fire protection is far from adequate on a large part of these private lands, especially on the cut-over timberlands. Reburns are frequent. Valuable timber reproduction has been replaced by brush, a change that materially increases the fire hazard. Cutting of private timber is often followed by tax delinquency and abandonment, which intensify protection difficulties. The net result of such conditions is a poorer watershed protective cover.

The drainages west of the Cascade Divide include approximately 1,897,000 acres of public domain and revested Oregon and California Railroad grant lands. The watershed-protective influence of these lands is classified as follows: approximately 1,200,000 acres, major; 482,000 acres, moderate; and 215,000 acres, slight. Timber is sold from the revested lands classified as timberland, but no provision is made for their permanent forest productivity. These lands are given some fire protection. No provision has been made, however, for protecting their timber from insects or disease, and bark beetles have killed immense quantities of the ponderosa pine. The net result of the policy governing the protection and use of these lands is a tendency toward less effective protection of watershed values.

Much true timberland in the Oregon and California grant lands has been classed by statute as agricultural land, and some of this, although unsuited to agricultural crop production, as a result of this classification has passed to private ownership, usually to be abandoned when the timber has been cut.

In a region of such steep slopes, high precipitation, and deep snows as that west of the Cascades, a high, dense forest cover, such as that formed by the existing coniferous stands, is essential to retard run-off, hold the soil in place, and prevent avalanches. The high timber values per acre of the virgin forest have resulted in large private holdings. Private lands are rapidly being cut over, and after cutting are largely devastated by fire. There is considerable doubt, therefore, whether the watershed requirements of these drainages as a whole will be adequately safeguarded if conditions continue as they are or become worse, as they can easily do. Public agencies should acquire about 5,000,000 acres of the private land on steep slopes. Approximately 100,000 acres of devastated forest lands should be replanted. Research is needed to determine how the forest cover of the Pacific Cascade slope can be made most effective in watershed protection and what use of the forest can be combined with maintenance of satisfactory watershed conditions.

SUMMARY AND CONCLUSIONS

The foregoing discussion has presented a picture of watershed conditions as they exist in the United States today. In view of the fact that the program necessary to correct the watershed troubles of the country is so intimately related to the conclusions, it has seemed best to combine the two. Accordingly, the reader is referred to the section "A Watershed Protection Program."

THE FOREST FOR RECREATION

By ROBERT MARSHALL, Collaborator

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VOLUME AND VALUE OF FOREST RECREATION

THE PRESENT VOLUME

The use of the forests for recreation probably dates to the time when some wandering savage, returning to his cave through the depths of the primeval forest, may have noticed a beam of sunlight shining on some darkened tree trunk and felt all at once without knowledge of the reason a moment of great, surging joy in the chaotic passage of his life.

Until very recently, the recreational enjoyment of the forest has been chiefly of this incidental nature. Today, however, forest recreation is no longer an unpremeditated matter. People do not, as a rule, live in the forest any more, and if they go there to enjoy themselves they are fully conscious of their purpose. Consequently they have come to realize that forest recreation has a definite value in their lives, that it is something for which they are willing to sacrifice time and money and so they desire to plan for the preservation of its possibility.

The word "recreation", as it is used in this report, means anything that is done directly for the pleasure or enrichment which it brings to life, in contrast with things that are done primarily to obtain the necessities of life. The diverse purposes of forest recreation and the many different forms which it assumes will be discussed later.

Table 1 shows in round numbers the best available statistics on the use of American forest lands for recreation during the year 1931. These figures are valuable not as giving a precise measure but for the general impression which they convey of the tremendous volume which recreational forest use has already attained in America.

TABLE 1.—*Recreational visitors to forest land in the United States in 1931*

Type of land	Number of visitors	Type of land	Number of visitors
National parks [1]	[2] 3,000,000	County and municipal parks [6]	[4] 60,000,000
National monuments	[2] 400,000	Private lands	[4] 100,000,000
National forests	[3] 32,000,000		
Other Federal lands	[4] 1,500,000	Total	246,900,000
State parks and forests	[5] 50,000,000		

[1] Exclusive of the urban Hot Springs National Park.
[2] National Park Service figures.
[3] United States Forest Service figures. About 24,000,000 of these recreationalists were transients who merely drove through the national forests.
[4] Estimates based on known use of limited areas of this type of land.
[5] National Conference on State Parks figures.
[6] Exclusive of parks within urban limits.

There is, of course, a great deal of duplication in these records. Some people visited several different parks or forests; some people visited the same area on a number of occasions and were checked separately each time; perhaps some people made use of all seven types of land for recreation. No doubt there were individuals who were counted more than a score of times in the total figure. It is therefore impossible to state how many different persons made recreational use of the United States forests during the year.

It is reasonable, however, to estimate that each visitor spent on the average one full day in each park, forest, or private timberland for which he was recorded. Some remained only for a few hours, it is true, but many remained several days, and a few spent the entire summer on a single forest area. If the estimate of one day per visitor is correct, a total of approximately 250 million man-days were spent during 1931 in recreational enjoyment of the forest.

The national parks and the national forests have kept count of the number of their recreational visitors since 1916 in the one case, and since 1917 in the other. These records started just prior to the era when long-distance automobile travel became mechanically and financially possible for a large proportion of our population, when consequently old notions of distances were altered almost overnight, and when entirely new recreational habits were formed by millions of Americans. The astounding increase in the number of both park and forest visitors, as shown in table 2, reflects the fact that forest recreation has grown during the past 15 years from a relatively unimportant variety of diversion into one of the most universally adopted forms of recreation.

There is, of course, considerable duplication in the records presented in table 2. The standards of tabulating visitors have varied considerably, also. Nevertheless the resulting inaccuracy probably is not of serious moment in the face of an apparent 750 percent increase in national-park use and an apparent 920 percent increase in national-forest use during the brief period of 14 years. The multiplication of the recreational use of these Federal lands has been not only tremendous in volume but virtually unbroken.

TABLE 2.—*Recreational use of national parks and national forests*

Year	Number of visitors to—		Year	Number of visitors to—	
	National parks [1]	National forests [2]		National parks [1]	National forests [2]
1916	237, 357		1924	1, 258, 178	11, 394, 366
1917	353, 268	3, 160, 000	1925	1, 495, 372	15, 279, 730
1918	311, 661	3, 322, 565	1926	1, 670, 955	17, 112, 024
1919	594, 835	3, 064, 344	1927	2, 173, 120	18, 523, 888
1920	756, 654	4, 832, 671	1928	2, 323, 089	23, 008, 997
1921	876, 367	5, 633, 420	1929	2, 496, 080	31, 758, 231
1922	938, 338	6, 172, 942	1930	2, 607, 499	31, 904, 515
1923	1, 168, 886	10, 543, 893	1931	2, 999, 451	32, 228, 613

[1] Exclusive of the urban Hot Springs National Park.

[2] The national-forest and national-park figures are not comparable because in recent years about three quarters of the national-forest visitors have been transients who merely drove through the forest area, while virtually all of the national-park visitors came for more protracted sojourns. The 1931 Forest Service figure which would be comparable to the Park Service record for the same year would be the 8,073,917 hotel and resort guests, summer-home guests, campers, and picnickers.

There is no reason to suppose that the general trends on Federal lands are different from those on other recreational territory. Consequently, it is fair to state that recreational use of forest lands is growing with tremendous acceleration.

THE FUTURE VOLUME

Is there reason to believe that this present growth in recreational use will continue? What factors are likely to inhibit and to stimulate future demand for forest recreation?

The most serious of the possible inhibiting factors seem to be commercial exploitation and fires, which threaten to deplete severely the beauty of many recreational areas. There can be no doubt that the greatest attraction of the forests is their natural beauty. If this is not adequately safeguarded, unquestionably millions who now delight above all else in the loveliness of the forest will forsake it for some other source of recreation.

Another of the possible inhibiting factors may readily be observed at any popular camp ground over a holiday. Here one sees swarms of tourists who not only destroy, by their mere numbers, the very isolation which was one reason for their journey to the forest, but also kill the ground vegetation around the camp site and tramp down the soil so compactly as even to kill many of the trees. This type of destruction has its remedy, like the destruction resulting from commercial exploitation, but unless the remedies are applied these factors will definitely tend to decrease the recreational use of the forests.

Factors which may be expected to stimulate recreational use of the forest are:

(1) *Increasing population.*—The predictions of reputable biometricians place the eventual saturated population of the United States between 145 million and 185 million. This represents an increase over present population of between 20 and 50 percent. It would in all likelihood result in a corresponding increase in the number of recreational seekers, even if no other factors were involved.

(2) *Shorter working hours.*—Whereas the average working week in 1929 ranged from 40 to well over 60 hours, with a mean for all in-

dustries somewhere around 50 to 55 hours, estimates for the not distant future place the average in some cases as low as 24 hours and in the majority of cases at least as low as 30 hours. This change would greatly increase the available leisure, and it seems reasonable to assume that a share of the additional leisure time would be devoted to forest recreation. If shorter working hours mean smaller income, however, the change may actually work against an increase in recreational use of the forest.

(3) *Probable rising standard of living.*—Most economists, whether they be capitalists or socialists, predict a great eventual improvement in the standard of living of the majority of American citizens. This means that millions of workers who cannot now afford to go to the forest will find it possible to make regular excursions to the woods. In many cases these excursions will probably be provided for at public expense. Already a number of cities perform such welfare work. It is not unreasonable to believe that sooner or later it may be considered just as much the function of public agencies to provide healthful recreation as to provide schooling.

(4) *Increasing ease of transportation.*—The advent of the automobile has decimated distances and made it possible for people living 500 miles from attractive forest areas to visit them as readily and cheaply as people a few years ago visited tracts but 50 miles away. With airplane and autogiro transportation rapidly being perfected and cheapened, there is every reason to believe that the forests will become still more accessible.

(5) *Increasing psychological necessity for escape to the primitive.*—As society becomes more and more mechanized it will be increasingly difficult for many people to stand the nervous strain, the high pressure, and the drabness of their lives. To escape these abominations, increasing numbers will seek the primitive for the finest features of life.

THE VALUE

An evaluation of forest recreation may be attempted upon either a monetary or a social basis.

In terms of dollars and cents, there are several ways of estimating the recreational worth of the forest. One is to determine the number of people who visit the forest annually, ascribe some average value to the pleasure which each one gets from it, and multiply. A second is to estimate the amount of money invested in forest recreation. A third is to figure the taxable wealth resulting from the recreational use of the forest. A fourth is to calculate the amount of money which recreationists spend in visiting the forests. The few figures available for each of these approaches will be presented as suggestive of the tremendous economic importance which forest recreation already assumes.

(1) It seems distinctly on the side of conservatism to estimate that each all-day visitor to the forest derives as much pleasure from it as he would derive from a 2-hour motion-picture show. On the basis of the best statistics available we have estimated that in the United States approximately 250 million man-days a year are devoted to forest recreation. If the admission price to a movie averages 25 cents, this gives the annual American forest recreation a value of

$62,500,000. This is what people probably would pay for the privilege of using the forest if the price were asked. The incidental fact that people have to pay for admission to the movies and do not usually have to pay for admission to the forest does not mean that the outdoor recreation is any less valuable.

(2) No inclusive figures are available for the amount of money invested in forest recreation. The special Senate Committee on the Conservation of Wild-Life Resources[1] estimates that "the investments which the Federal and various State Governments have made for the purpose of preserving or increasing wild life comes to a total of $507,134,935." The total amount of money so far spent in the purchase of State parks and forests used primarily for recreation amounts to nearly $50,000,000. The annual expenditures by States for forest recreational developments, including chiefly the maintenance of parks and reservations, amounted in 1929 to $4,612,711.

In New England alone, it is estimated, $550,000,000 is invested in recreational property.[2] Of all New England's recreational appeals, the dominant ones are natural surroundings among which lakes and mountains rank first.[3] Consequently a very considerable proportion of the $550,000,000 recreational investment may be attributed to forest recreation.

In Wisconsin[4] "it has been estimated that the investment in a resort area 40 miles square in the highland lake district is almost $40,000,000."

In view of the $40,000,000 estimated to have been expended on the area 40 miles square in Wisconsin, it is interesting to speculate what amounts may have been invested in such extensive, popular, and much-developed forest playgrounds as California, Colorado, or the Adirondacks.

(3) Private recreational investments in many regions bear an especially important relationship to the rural tax problem. It has been found, for instance, that recreational lands contain 37 percent of the tax base in Oneida County, Wis., and 63 percent of the tax base in Vilas County, Wis. In these counties "even on the acre basis, recreational land is usually assessed for more than farm land or merchantable timber."[5]

It is impossible even to estimate how much taxable wealth results from forest recreation in the entire United States. A material fraction of the billion dollars of taxes paid in 1931 on motor vehicles and gasoline must be prorated to forest recreation. In addition there are the taxes on forest hotels, resorts, residences, and services; on scenic railroads, trolley lines, and tramways; on camping clothing and other equipment; and on the manufacture and sale of arms and ammunition. The sum of all these taxes certainly involves a huge total.

Of course much of this tax bill would be collected even if there were no forest recreation. If people could not go to the forest, a good many of them would take their vacation tours somewhere else. Similarly, if the people who now have woodland summer homes were obliged to give them up, a goodly percentage would be content with seashore dwellings. But the substitutability noted in forest recreation applies equally to any other resource. The taxable wealth resulting from the commodity use of the forest also would be greatly reduced if all the possible commodity substitutions were effected.

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[1] Wild Life Conservation, Senate Report No. 1329, 71st Cong., 3d sess., 1931.
[2] New England Council News Letter, Nov. 19, 1931.
[3] "New England's Recreational Appeals," Laurence W. Chidester, 1930.
[4] Forest Land Use in Wisconsin, committee on land use and forestry, Madison, Wis., 1932.
[5] "Recreation as a Land Use," George S. Wehrwein and Kenneth H. Parsons, Agricultural Experiment Station, Madison, Wis., 1932.

(4) The American Automobile Association estimates that almost $4,000,000,000 was spent in motor camping and vacation motor travel in the United States during the year 1929. It does not seem unreasonable to assume that one quarter of the vacation motor travel is through forested country, and this would mean that annual forest vacation motor expenditures amount to about $1,000,000,000.

The Special Senate Committee on Conservation of Wild-life Resources[6] calculates that in 1929 hunters and fishermen spent $650,000,000 in addition to transportation expenses. It would be conservative to estimate that at least three quarters of this enormous sum was spent on forest hunting or fishing, which would mean that this form of forest recreation accounts for an annual outlay of approximately half a billion dollars.

No national figures are available for the amount of money spent each year on summer homes, hotel, and resort accomodations (other than those paid for by automobile tourists), hiking equipment, or the outfits required for wilderness journeys. These expenditures would unquestionably run half as high as those for hunting and fishing. Consequently the following would seem to be a reasonable, although admittedly a very rough, estimate of the amount of money spent on forest recreation during the peak recreation year of 1929:

Forest vacation motor travel	$1, 000, 000, 000
Hunting and fishing	500, 000, 000
Summer homes, resorts, hiking, wilderness journeys	250, 000, 000
Total	1, 750, 000, 000

Although huge sums of money are involved on any basis of calculation, the most important values of forest recreation are not susceptible of measurement in monetary terms. They are concerned with such intangible considerations as inspiration, esthetic enjoyment, and a gain in understanding. It is no more valid to rate them in terms of dollars and cents than it would be to rate the worth of a telephone pole in terms of the inspiration it gives. The only common denominator for the recreational and commodity value of the forest is the human happiness which may be derived from each use. Unfortunately no quantitative measure of human happiness has ever been designed, and consequently it is impossible to describe accurately the contribution which forest recreation makes toward the welfare of mankind. About all one can do is to point out the purposes for which men seek the forest and let each reader make his own evaluation of their intrinsic importance.

PURPOSES

Perhaps the most frequent purpose of those seeking forest recreation is simply to have a good time in the outdoors. The majority of vacation motorists enjoy what features of the forest they can observe at a velocity of 40 miles an hour, but never really transfer their lives from the highway to the forest. The woods are only a pleasant background for a type of satisfaction which could be enjoyed with no essential diminution in any open-air environment. The urge to go somewhere and the desire for amusement and a change from everyday life are the vital concerns with this particular type of recreationist.

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[6] Wild Life Conservation, S.Rept. 1329, 71st Cong., 3d sess., 1931.

Millions of people go to the forest for the preservation, restoration, or stimulation of their health. The therapeutic value of forests has long been recognized in selecting sites for sanitoria. More recently it has come to be realized that healthy people may be immensely benefited by the pure air, the wholesome exercise, and the relaxation which are such important attributes of forest recreation.

There are many people whose primary concern in the forest is the pursuit of beauty. The joy which such people derive from a sunset across some forest lake, from the unfathomable immensity of the panorama off some wilderness summit, from the unmarred splendor of a virgin forest, is not essentially different from what another esthete might derive from the paintings of Rembrandt, from the sulpture of Rodin, from the music of Beethoven, from the drama of Shakespeare, or from the poetry of Keats. In spite of the analogy with these artistic forms of beauty, the forest has unique values which make it a most distinctive source of esthetic pleasure.

Closely allied with the pursuit of the beautiful is the desire for communion with nature. For many people there is a significance, as vital and as satisfying as that which any communicant ever derives from feeling his spirit one with God, in feeling themselves to be one with nature, in cutting all bonds of habit and drifting into the timeless continuity of the primeval.

The primeval environment often proves exceptionally inspiring and exceptionally favorable to contemplation. Many of our greatest American thinkers—men of the caliber of Thomas Jefferson, Henry Thoreau, Mark Twain, William James, and John Muir—have found the forest an effective stimulus to original thought. John C. Merriam has well remarked:[7]

> The man or woman who goes to Grand Canyon or Yellowstone or Yosemite for a week's vacation is cut off, for the moment, from the business of making a living. Nearly all of the small cares that make up a good part of our ordinary living are also left behind. Under such conditions the mental and spiritual processes turn not only toward appreciation of nature but toward enjoyment of intellectual life. Frequently at such times consideration is given to the greatest of our problems. The most intimate and deepest spiritual experiences may develop and great decisions be made.

Some visitors to the forest are primarily interested in its scientific aspects. They want to study the forest, to learn the fundamental reasons for its development, to appreciate the causes of the functioning of its myriad component parts. To them the forest is a laboratory, unbounded by the conventional four walls, floor, and ceiling of the usual research center but fully as significant in the development of a knowledge of the laws of nature.

The tradition of the pioneers is inculcated into most American children even before they start their schooling. All through their formative years they read about the glorious adventures of the American frontiersmen, and often they relive in games and imagination the stirring pioneer days. Many of them grow up to long for some real adventure and become sick and tired of getting their thrills in such vicarious forms as the lurid movie, the cheap novel, or the travelogue. A depressingly large number of the more energetic of these malcontents try to appease their unfulfilled yearning in the pursuit of crime and racketeering. Others long for a declaration of war in the hope that in battle they may capture some of the rightful thrills of life. This same psychological urge lures some people to the forest, where in less antisocial ways than crime and fighting they add genuine dash of adventure to their lives.

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[7] Educational Values of Recreation, Educational Record, October 1932.

Finally, there are those whose chief purpose in visiting the forests is simply an escape from civilization. These people want to rest from the endless chain of mechanization and artificiality which bounds their lives. In the forest they temporarily abandon a life to which they cannot become wholly reconciled and return to that nature in which hundreds of generations of their ancestors were reared.

It is patent that people who go to the forest with such different purposes will find their recreation in many different forms. Some of them will tour the forest, or temporarily reside in it, without having recourse to any means of transportation other than the mechanical. Others will resort principally to natural means of transportation in the course of hiking, riding, canoeing, hunting, fishing, or traveling the wilderness. Of course many of these must use mechanical modes of transportation to reach localities where they can make use of the natural modes.

The differentiation between forms of recreation employing mechanical transportation and those employing natural transportation is of fundamental significance. In the former case the recreationist considers nature a mere background to his enjoyment; in the latter he becomes for a while a part of nature. When a man travels in the forest by natural means all his capability and all his understanding are called into use, and an infinite number of subtleties which cannot possibly be discovered from the highway, the camp ground, or the house are clearly appreciated and become vitally significant to him. On the other hand millions of people who enjoy the forest in the luxury of mechanical transportation would not dream of undergoing for pleasure the hard work which delights the hiker or canoeist. The mechanical modes of transportation appeal to those who desire especially comfort, speed, and a superficial acquaintance with many areas. The natural modes are chosen by those who want adventure, freedom from the rush of life, and an intensive knowledge of small areas.

There is no object in trying to compare the different forms of forest recreation as to importance or value. Each form has at least tens of thousands of devotees who prefer it to any of the other forms. We cannot say that if fish and game resources become exhausted fishermen and hunters will be satisfied with hiking, or that if we cut up all our large wilderness areas those who in the past enjoyed wilderness travel will enjoy automobiling just as well. For large numbers of people such losses would represent an irreparable destruction of the richest aspects of life. A rational program for forest recreation in America must assure to the adherents of each of the different types of enjoyment an ample opportunity to indulge their desires.

TYPES OF RECREATIONAL FOREST AREAS

The varied purposes of those who seek recreation in the forest, and the different forms that the realization of these purposes assumes, necessitate recognition of several distinct types of recreational forest areas. Since each of these types has its special standards of size, beauty, and administration, and since therefore a separate recreational program must be developed for each, it is well to explain their character and function.

SUPERLATIVE AREAS

"Superlative areas" are localities with unique scenic value, so surpassing and stupendous in their beauty as to affect almost everyone who sees them. Examples of such superlative areas are the Grand Canyon, Crater Lake, the Canyon of the Yellowstone, the mountains of Glacier National Park or the Teton Range, the Valley of Yosemite, and the Big Trees. This category includes also natural features of exceptional scientific interest such as the geysers of the Yellowstone and the Carlsbad Caverns in New Mexico. If any of these areas should be destroyed or seriously injured there would be no substitutes.

Most American citizens are enthusiastically convinced of the importance of thoroughly safeguarding the inspiring beauty of these areas. Even those least appreciative of recreational values are generally willing to admit that we should reserve our relatively few superlative areas. Consequently it will not be necessary here to justify the retention of such tracts for recreational purposes. Already most of them have been set aside in national parks. A number are located in national forests, national monuments, and State parks, where their unique values are adequately safeguarded. A few remain in private ownership. The last mentioned should be acquired by public agencies.

No maximum or minimum size can be assigned to superlative areas. Each superlative feature is a law unto itself, demanding preservation of the entire area which it occupies and of a certain terrain from which it may be viewed.

PRIMEVAL AREAS

"Primeval areas" (sometimes called natural areas) are tracts of virgin timber in which human activities have never upset the normal processes of nature. They thus preserve the virginal growth conditions which have existed for an inestimable period.

Primeval areas have two different values. First, they are of great scientific significance. They are an absolute necessity for any future studies of the natural distribution of the flora and fauna of the world. Further, in trying to plan methods of cutting which will assure the perpetuation of the forest, it is of utmost importance to have various unmodified stands with which to compare the results of human modification. Innumerable laws of nature can never be thoroughly understood without some access to the conditions of the primeval. These scientific values are quite generally recognized, and both the Forest Service and the Park Service are making provisions for preserving them.

The importance of the primeval in the more subtle aspects of forest recreation is much less generally recognized. Yet observation of many recreationists gives convincing evidence that most of those who visit the forests for contemplation, inspiration, communion with nature, or enjoyment of the beautiful receive very much more pleasure from the beauty of primeval areas than from the beauty of areas modified by man. To argue that because lovers of the woods get some enjoyment from cut-over lands it is unnecessary to finance the retention of samples of the primeval would be as unconvincing as to argue that because lovers of music may get some enjoyment from the concerts of mediocre pianists it is unnecessary to finance a Paderewski or a Rachmaninoff.

It seems necessary not only to reserve samples of the primeval but to reserve a considerable number of such samples in every important forest type in the country. There are at least three important reasons for this: First, in order to avoid such overcrowding as would speedily destroy primeval conditions; second, to make the advantages of primeval areas readily accessible to people in as many different parts of each forest region as possible; and third, because there is still so much danger that any forest stand will be wiped out by fire or insects. Therefore, unless it is already too late, at least half a dozen primeval areas should be set aside in every forest type.

It is not reasonable to contend that if all the samples of primeval conditions in one forest type were destroyed other forest types would do as well. Each timber type has its own unique charms, its own unduplicated manifestation of beauty the destruction of which would distinctly lessen the potential esthetic enjoyment of nature. There are as great differences between the beauty of the redwood, the Engelmann spruce, the western white pine, the northeastern hardwood, the southern pine, and the cypress forests as there are between the paintings of De Vinci, Turner, Rembrandt, Sargent, Goya, and Diego de Riviera. If anyone proposed that public expenditures for the housing of art should be reduced by disposing of the works of Turner, Sargent, and De Riviera, because their paintings are less distinguished than those of the others the suggestion would be greeted with uproarious derision, because everyone knows that art cannot be relatively evaluated, and that it is of the utmost importance to preserve the finest example of each important type. Similarly no defensible rating can be made of the relative beauty of timber stands, and consequently each important type should be preserved in the museum of the forest.

In general, the same primeval area may be put to scientific and recreational use. On certain areas, however, recreational use will have to be entirely barred in order to permit undisturbed research. In any event, visitors to primeval areas will be subjected to certain restrictions. Except on spacious areas it will not be possible to permit camping, for any great amount of such activity tends to deteriorate the primeval with exceptional rapidity. Where there are large numbers of visitors it will be desirable to construct trails through the area to save underbrush and reproduction from trampling.

The minimum area necessary for the maintanence of primeval conditions varies with forest type, climate, and topography. In general the Forest Service believes that 1,000 acres is about the smallest area desirable, though in special cases where so much as 1,000 acres of virgin forest cannot be found the largest available area will have to be sufficient. A tract of 1,000 acres, while well adapted for research, is too small for satisfactory recreation. The person with a yearning for the beauties of the primeval wants to do more than just stroll into a virgin stand of timber and squat. He desires to be able to walk around in it for a considerable period, losing himself entirely for a while in its timeless beauty, forgetting that there is such a thing as a machine-age world. This is extremely difficult to do in 1,000 or even 5,000 acres. While the figure varies considerably with timber type, a primeval area should contain not less than 5,000 acres, which is, after all, scarcely 8 square miles. Wherever possible, tracts of at least double that area should be set aside.

Table 3 shows the major timber types in the United States and the number of primeval areas of even 5,000 acres which have been set aside in each. It will be observed that little progress has been made in reserving primeval areas of even the minimum size. It is vitally important that any additional areas which are to be preserved should be set aside right away, for without early action the possibility of maintaining primeval areas in a number of important timber types will be lost, if, indeed, it has not been lost already.

TABLE 3.—*Number of 5,000-acre primeval areas reserved in each major forest type*

Forest type	Total	National park	National forest [1]	State
Spruce and fir	11	1	0	10
Jack, red and white pine	0	0	0	0
Northeastern hardwood	3	0	0	3
Chestnut, chestnut oak, and yellow poplar	1	1	0	0
Oak and pine	1	1	0	0
Oak and hickory	1	1	0	0
Cypress, tupelo, and red gum	0	0	0	0
Southeastern pine	0	0	0	0
Ponderosa pine	3	3	0	0
Sugar pine and mixed conifer	2	2	0	0
True fir	2	2	0	0
Redwood	2	0	0	2
Sitka spruce	0	0	0	0
Douglas fir	2	2	0	0
Lodgepole pine	7	7	0	0
Engelmann spruce	5	5	0	0
Subalpine	7	7	0	0
Western white pine	0	0	0	0
Larch and douglas fir	1	1	0	0
Aspen	1	1	0	0

[1] The Forest Service has established 16 smaller areas, between 160 acres and 4,230 acres, and averaging about 1,250 acres each.

This list of forest types excludes several distinctive minor types which are so limited in distribution that it would be impossible to attain the minimum standards of either number or size which were set for the major types. In each minor type at least one primeval area, as large as possible should be set aside. These minor types include the pitch pine, southern white cedar, mangrove, port orford cedar, jeffrey pine, monterey pine, and mountain hemlock types. Provision is already being made for the reservation of all existing stands of Bigtree.

WILDERNESS AREAS

"Wilderness areas" are regions which contain no permanent inhabitants, possess no means of mechanical conveyance, and are sufficiently spacious that a person may spend at least a week or two of travel in them without crossing his own tracks. The dominant attributes of such areas are: first, that visitors to them have to depend exclusively on their own efforts for survival; and second, that they preserve as nearly as possible the essential features of the primitive environment. This means that all roads, settlements, and power transportation are barred. But trails and temporary shelters, features such as were common long before the advent of the white race, are entirely permissible.[8]

It will not be possible to preserve primeval forest conditions through the whole of any tract large enough to fulfill these requirements. Indeed there may be some wilderness areas, as for instance in Maine, where practically the entire tract will have been logged. The difference between primeval and wilderness areas is that the primeval area exhibits primitive conditions of growth whereas the wilderness area exhibits primitive methods of transportation. Of course wilderness areas may contain within their boundaries much that is primeval. Their chief function, however, is not to make possible contact with the virgin forest but rather to make it possible to retire completely from the modes of transportation and the living conditions of the twentieth century.

In 1930, the United States Forest Service adopted the policy of reserving portions of its territory from road or residential development. The Park Service had meanwhile enunciated the policy of preserving most of its territory in a state of roadlessness. Under these two administrative policies it will be possible to preserve an adequate number of wilderness areas in the West. In the East the situation is less favorable for except in New York and Minnesota the potential winderness areas are almost exclusively controlled by States or private owners having no policy of preserving wilderness conditions.

Wilderness areas in general will have to be sections of high mountain country where commercial values are low, because practically all of the more accessible and productive lands have already been subjected to development. The great bulk of the remaining potential wilderness areas could not possibly be managed for timber production. Their inaccessibility and the low quality and slow growth of their timber would render futile any hope of either a financial profit or a sustained yield. The fact that most of the wilderness areas will of necessity be low-grade land will make the cost of maintaining them much less serious than their large acreage might lead one to expect. Further, a great part of such land will need to be reserved anyway, as protection forests for the control of stream flow and the prevention of erosion.

Cattle or sheep grazing is not incompatible with wilderness use. In occasional instances storage reservoirs may be permissible. On a number of wilderness areas, logging will be allowed, though in most of these tracts the timber will be so remote that cutting operations will not be feasible. For fire-protection purposes it will be necessary in most parts of the West to permit telephone lines and lookout cabins within wilderness areas and to permit airplane transportation of men and equipment. Otherwise, wilderness areas should be kept as much as possible in their pristine wildness.

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[8] The Problem of the Wilderness, Robert Marshall, the Scientific Monthly, February 1930.

As regards area, no absolute limits can be set. Americans who want wildernesses of the sort which existed in frontier days will need to retreat to the more remote expanses of northern Canada and Alaska. Some semblance of pioneer conditions might be obtained in tracts of more than a million acres, of which several still remain uninvaded by roads. For those wishing to spend one or two weeks in wilderness travel without retracing their routes, 200,000 acres (about 300 square miles) is the least area that would generally prove satisfactory. In this report that acreage has been adopted as the minimum size for a wilderness. In many cases smaller units have a great recreational value, but it is not the value of wilderness travel, and consequently such tracts will not be considered as wilderness areas.

There remain today in the United States only 9 areas of 1,000,000 acres or more, 18 areas of 500,000 acres or more, and 38 areas of 200,000 acres or more which could still be set aside as wilderness tracts without involving any serious sacrifice of commercial values, any great risk to adequate fire protection, or any major changes in existing highway plans. These tracts total about 26,950,000 acres. Approximately 8,425,000 acres in the East is almost entirely covered by forest. The 18,525,000 acres in the West includes at least 7 million acres of nonforested land. This leaves about 20 million acres of wilderness in a forested condition. As has been explained, almost no sacrifice of economic values would result from preserving these forest areas as wilderness. The only sacrifice involved would be in barring tourists. In view of the fact that 486 million acres of forest land in the country would remain subject to highway development, it would not seem unreasonable to bar mechanized development from 20 million acres.

The wilderness journey is still relatively unusual, both because for full enjoyment it requires considerable facility and training, and because it is expensive. Only a strong and experienced woodsman can pack on his back the necessary equipment for more than a week of wilderness travel. The great majority of wilderness travelers must buy or hire pack horses or boats, or employ back-packers. Unless they have had considerable experience in the woods they must also employ guides. Consequently, although a competent man can take a 2-week wilderness journey with one pack horse for $30, most people would require a couple of horses and a guide at a cost of at least $125, even if they do not have to buy special clothing and camp equipment. A month's trip with an elaborate outfit in especially inaccessible country may easily cost one man $1,000.

In the future, however, as more and more people learn how to care for themselves in the woods, and above all as wilderness journeying becomes recognized as an important and exceptionally virile form of recreation, a decrease in cost of participation may be expected similar to that which has accompanied the development of other popular pastimes. Furthermore, the heightened standard of living which it is reasonable to predict for the future may be expected to make travel in the wilderness a possibility for tens of thousands who today yearn futilely for such adventure.

In consequence, a greatly increased amount of journeying in the wilderness may fairly be expected. It would seem reasonable, therefore, to establish as wilderness areas all tracts for which no definitely higher present utility exists. If in the future the use of these tracts does not justify their retention as wilderness areas, it will always be possible to cut them up with additional roads. But once roads are built, it will be very difficult to restore the wilderness. In table 4 are listed the 38 established, partly established, or potential wilderness areas.

TABLE 4.—*Forest wilderness areas, established and potential*

Name of area	State	Acreage	Ownership	Present status
Central Idaho	Idaho	3, 375, 000	National forest	Part established.
Aroostook-Alagash	Maine	2, 825, 000	Private	Potential.
South Absaroka	Wyoming	1, 825, 000	National forest, national park	Established.
Upper St. John	Maine	1, 300, 000	Private	Potential.
Superior	Minnesota	1, 275, 000	National forest, private	Established.
High Sierra	California	1, 075, 000	National forest, national park	Do.
South Fork	Montana	1, 050, 000	National forest	Part established.
Glacier-Bridger	Wyoming	1, 050, 000	National forest, Indian reservation	Do.
North Cascade	Washington	1, 025, 000	National forest	Potential.
North Absaroka	Wyoming	825, 000	National forest, national park	Established.
Snoqualmie	Washington	800, 000	National forest	Potential.
Sysladopsis	Maine	775, 000	Private	Do.
Olympic	Washington	725, 000	National forest	Part established.
Dead River	Maine	600, 000	Private	Potential.
Nantes Mountains	Arizona	575, 000	Indian reservation	Do.
Gila	New Mexico	575, 000	National forest	Established.
North Glacier	Montana	550, 000	National park	Do.
Moose River	New York	500, 000	State, private	Do.
North Yosemite	California	475, 000	National park, national forest	Do.
Aquarius Plateau	Utah	475, 000	National forest	Potential.
Mount Marcy	New York	450, 000	State, private	Established.
Pitchstone Plateau	Wyoming	450, 000	National park	Do.
Okefenokee	Georgia	400, 000	Private	Potential.
South Glacier	Montana	400, 000	National park	Established.
South Yosemite	California	350, 000	National park, national forest	Do.
Madison Plateau	Wyoming	350, 000	National park	Do.
San Juan	Colorado	300, 000	National forest	Do.
Oven Lake	New York	300, 000	State, private	Do.
Goat Rocks	Washington	250, 000	National forest, Indian reservation	Part established.
Salmon Trinity Alps	California	250, 000	National forest	Do.
High Uintas	Utah	250, 000	do	Established.
Marble Mountain	California	250, 000	do	Do.
Beartooth	Montana	225, 000	do	Do.
Eagle Gap	Oregon	225, 000	do	Do.
Grand Teton	Wyoming	225, 000	National park, national forest	Part established.
Central Plateau	do	200, 000	National park	Established.
Bighorn	do	200, 000	National forest	Potential.
Mission	Montana	200, 000	National forest, Indian Reservation	Part established.

ROADSIDE AREAS

The great majority of people who visit the forests for recreation do so by automobile. While most of these visitors do not penetrate into the forest, they are very much concerned with the part which they can see from the highway. If this were destroyed or seriously damaged, their enjoyment of touring would be immeasurably impaired, and indeed many of them would largely give up their vacation journeys. Consequently, it follows that for these people it is of great importance to preserve from serious scenic damage the timbered strips adjoining the more important roads. These strips will be referred to as "roadside areas." This classification will include also strips of timber left along lakes, rivers, and all other boat and canoe routes.

Obviously it would not be feasible to preserve scenic strips along all the 3,009,000 miles [9] of highways in the United States. Many of the highways receive only occasional use, and the great majority are rarely visited by people in quest of recreation. However, it would seem that the 324,500 miles of State highways receive sufficient use to justify protection of roadside areas. Therefore, wherever State highways pass through forest lands, it is recommended that strips of land at either side of the roadway be preserved on which scenic values will not only be safeguarded where they already exist but also restored through planting, the elimination of billboards, the tearing down of ramshackle houses, and cutting to open attractive vistas.

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[9] Estimate given in Facts and Figures of the Automobile Industry, National Automobile Chamber of Commerde, 1932.

About a quarter of the land area of the United States is covered with forest, but roads do not sample all this territory equally. They are much more apt to lead through fields and clearings. It would be liberal to estimate that one sixth the State highway mileage, or about 54,000 miles of such road, leads through forests. If there were added to this figure a nearly equal mileage of county and local roads having particular recreational value it would mean that a maximum of about 100,000 miles of roadside strips should be retained to give scenic protection to the highways.

The width desirable for these strips varies with the density of the forest, the topography, and the danger of windfall. Along roads that are used chiefly in summer, when forest visibility is much less than in winter, the strips can be narrower. In most cases the width of the strips on each side of the road should probably range from 125 to 250 feet, which would be sufficient to hide any impairment of the scenery behind them.

CAMP-SITE AREAS

For the benefit of the many automobilists and boat travelers who spend their nights in camp, it is important to provide "camp-site areas." These will not only make camping more comfortable and convenient for the travelers, but will also curtail the very serious damage to forests which results when the hordes of tourists who throng many popular highways camp chaotically through the surrounding woods.

The minimum area desirable for individual camp grounds is difficult to determine precisely. Probably one-quarter acre is about the least size to which a single tent site could be contracted and still retain reasonable isolation for the camping party which occupies it, though in many cases isolation is what the campers do not desire. However, too great crowding also tends to deteriorate the camp site. The number of tent sites on a camp ground may vary from one to upwards of a thousand.

In general it is desirable to locate camp-site areas some distance back from highways. This spares the camper the continual dust cloud raised by passing automobiles, and spares the tourist constant interruption in his enjoyment of the forest. To a certain extent the location of camp grounds will be determined by the occurrence of water, though wells and preferably piped water will make almost any area available for this use. In many populous parts of the country practically every possible camp ground should be developed. The laying out of camp-site areas calls for landscape architecture and recreational planning of high quality.

Camp-site areas may sometimes be necessary along much-frequented trails in order to avoid a haphazard camping which would seriously mar scenic beauty and wildness. The State of Maine has found public camp sites in the interior of the forest most desirable from a fire-prevention standpoint. In most cases, however, camp grounds away from roadsides and main trails and boat lanes are undesirable because they give the recreationalist an unnecessary impression of the very regimentation and artificiality which he is seeking to avoid.

RESIDENCE AREAS

"Residence areas" provide space for private homes, hotels and resorts, group camps, sanitoria, and stores and services of one sort or another. They are in most cases privately owned, though the national forests in 1931 furnished summer-home sites for some 493,235 special-use permittees and their guests. The rent which the Government got from the summer-home sites in that year amounted to more than $150,000. For the acreage involved this was the best paying activity which the Forest Service undertook. Many of the better-run private residence areas have been sources of great profit to their owners. There is here no conflict with commodity exploitation because the returns from recreation are so much greater than they could be from any other source.

About one-quarter acre is the minimum desirable area for a single forest residence. One acre would probably not be an unreasonable average, for both public and private land. Of course a few immense private estates run into thousands of acres, but only a small fraction of each of these tracts could fairly be considered a residence area. A store or service station generally necessitates a little less acreage than a private home, while a hotel or a group camp requires considerably more.

OUTING AREAS

While for many people the automobile tour in itself supplies every want, increasing numbers of people desire more intimate contact with the woods. Their first trip may be confined to the highway, but soon a curiosity as to what lies beyond the roadside fringe is aroused, and they return to find out. Once the joys of intimate contact with the forest are discovered, the idea of taking a vacation exclusively on the highway seems almost as preposterous as it would seem to have moving sidewalks established in picture galleries so that one might enjoy the paintings without stopping.

These people may be interested only in an afternoon's walk or an all-day hike or at most in an overnight trip. They do not require the large expanse of a wilderness and may not have ready access to any superlative or primeval areas. Consequently, yet another type of recreational area is needed. This type of area will be referred to as an "outing area."

For this use any tract of forest on which one can get away from the sounds of the highway and which has not been severely injured scenically will be acceptable. The outing areas will thus be intermediate between primeval areas and commercially operated timber tracts. In most cases it will be perfectly possible to combine sustained-yield forestry with the recreational use of outing areas. While even the best silviculture generally injures the æsthetic value of a forest for many years, there are high recreational values on most well-managed timber areas at least during the second half of the rotation. Obviously, recreational use and timber operation can never be combined unless there is assurance of sustained yield. In view of the almost uniform failure of private owners to practice sustained-yield forestry, it is virtually imperative that where there is combined timber and recreational use the area must be in the hands of the public.

Throughout the East a good part of the forest hiking will have to be done in outing areas. In the West outing areas are often important adjuncts to popular residence areas. An example is the Desolation Valley in California, a tract of 41,000 acres near the much-visited Lake Tahoe. This basin has neither remarkable beauty nor remarkable timber, yet the Forest Service has set it aside exclusively for recreational use. It is much too small for any real wilderness journey, but is splendidly adapted for a day's walk or an overnight trip.

The character of outing areas will depend on what forest is available. In certain devastated sections of the East the most beautiful stands of timber remaining are such as might not even be considered for recreation in most regions. On the plains the only forest will generally be plantations which, although in their particular locality they may seem of surprising beauty, in other parts of the country would appear exceptionally unattractive.

Outing areas will have special value as buffers for superlative and primeval areas. Superlative areas tend to attract large numbers of people. If these crowds are permitted to camp in the midst of the most stupendous scenery, they seriously distract the onlooker, for a throng of tourists does not seem to blend with surpassing natural beauty. Yet hotels, camp grounds, and various services are needed for the crowds which visit these superlative areas. Hence arises the desirability of attractive buffers adjacent to the unique phenomena which draw the tourists. Here the large number of visitors can reside comfortably and amid pleasant surroundings, and yet not mar by their presence the value of the beauty which they came to enjoy.

The need of outing areas as adjuncts to many of the primeval areas is quite different. Primeval areas will generally be small, simply because in most forest types no large tracts of virgin timber are available. Any development of trails within these small primeval areas should link with forests outside, so that the pedestrian or horseback rider may not be confined in his enjoyment to the relatively brief time it takes to travel through the primeval forest. Such outside trails should lead through forest areas characterized by a considerable degree of beauty. Often this will necessitate the exclusion of all logging from the buffer forest.

The size of outing areas will vary from a few acres up to the lower size limits of wilderness areas. In general such areas will be distinguished by their accessibility, and this will tend to curtail the possibility of large dimensions.

THE PROBLEMS OF FOREST RECREATION

USE WITHOUT DESTRUCTION

Anybody who visits the popular outing centers near the large American cities on public holidays cannot fail to be impressed by the immense number of people in search of forest recreation. Almost every possible open spot along the highways will be filled with picnickers and campers cooking their meals, pitching tents, playing games, swinging from trees, and noisily giving vent to pent-up childlike impulses which are rigidly curbed under city regimentation. At night time it sometimes seems almost as if every tree and every bush sheltered a sleeping figure. Such heavy use does more than kill the possibility of enjoying one of the chief recreational values of the forest, its privacy and quiet. It threatens to destroy the forest itself.

This damage to the forest comes from several sources. Small trees are cut down for fuel and tent poles. Reproduction and underbrush which gets in the way is removed. Trees and the lesser vegetation are killed by abrasion. Gas and oil leaking from cars onto the forest floor seriously injures all forms of plant life. Finally, the mere constant tramping on the forest floor kills the moisture-absorbing, nitrogen-providing ground cover, and packs down the soil so firmly that proper areation for the roots of the trees becomes impossible. Many much-frequented camp grounds originally laid out in beautiful groves have become virtually deserts, with the few remaining trees all sickly, with the undergrowth and reproduction virtually extinct, and with the surface of the camp ground merely bare soil which in wet weather becomes a slimy mud and in dry weather gives off a constant cloud of dust.

The remedy for such intolerable conditions is fourfold. It is first of all essential to set aside a sufficient quantity of camping ground in the vicinity of large centers of population that no camp site will be overused. How many camp sites will be needed for each community is a subject for individual study, involving a consideration of the population, its present and probable future recreational habits, the quantity of other types of recreational land accessible for use, and finally the susceptibility to damage of each type of forest available for camp sites.

A second important remedy is to educate the public in the proper use of camp sites. There is an immense difference between the damage caused by careful, considerate campers and that caused by campers who appreciate nothing except their own immediate pleasure. Lack of regard for social values is in most cases not willful but simply thoughtless. Much of the misuse and destruction of public camp sites could be eliminated by educating people in a consciousness of the necessity for care with fire, prevention of needless damage to trees and other vegetation, cleanliness in garbage disposal, and reasonable consideration of the peace of neighboring campers.

There is need also for careful planning of camp sites so that cars may be parked, tents pitched, camp fires built, and meals eaten at definite places instead of all over the camp ground.[10] In this way the quantity of vegetation destroyed by camping can be greatly reduced and much more efficient use can be made of the available space. Enough well planned camp sites are already in use to indicate clearly how much better the forest values are protected on such areas.

Finally, it is desirable to have definite regulation of all camp grounds. In the case of large, much-frequented camp-site areas this will necessitate a resident administrative officer; in the case of smaller, less popular areas, an occasional visit by an inspector. The administrator will see that necessary regulations are enforced, he will help to educate the camp-ground users as to the desirability of good camping manners, he will assist them where they require help, he will build fireplaces, garbage receptacles, driveways, he may in some cases even procure fuel for campers, and he will clean up any mess they may leave behind and repair any damage that can be repaired.

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[10] A Camp Ground Policy, E. P. Meinecke, 1932.

The problem of use without destruction is in many respects even more critical in the case of primeval areas. The only reason it is not in all respects more critical is that fewer people visit primeval areas, unless the areas are along main routes of travel, as in the case of the California redwood groves.[11] Primeval areas are the result of a very delicate balance of natural conditions. As soon as they become overrun by hordes of people the original conditions are upset and the natural balance of the forest destroyed. To prevent this it will generally be necessary to prohibit camping, most destructive of the recreational uses of the forest, in all primeval areas except a few of the most extensive. Where camping is permitted it will have to be confined to specially prepared camp grounds. Trails will have to be constructed through the areas so that the great bulk of people, instead of tramping promiscuously over everything, will limit their wanderings to the pathways.

PRESERVATION FROM NATURAL ENEMIES

Areas of forest land that are devoted to recreation require just as serious protective measures as do commodity areas. Fires, insects, and fungi may in fact be even more destructive to recreational than commercial values. Dead trees often have a salvage value as commodities, but there is no way of salvaging the destroyed beauty of a ruined forest.

In spite of the best protective efforts, however, there is one natural enemy against which the primeval forest can not in the long run be protected. This enemy is senility. Sentimental conservationists talk glibly about setting aside virgin timber tracts to be preserved in all their natural glory forever. Nevertheless relatively few forest trees live beyond 400 years. What is a beautiful virgin forest today may in 40 years be a very ragged stand in which most of the old trees are dying and in which the understory will require a century or more to attain the size and beauty of the former forest. There is good evidence that in the past great areas of overmature timber were wiped out by widespread insect epidemics, often followed by fire.

Just recently the disastrous mountain pine beetle epidemic among the lodgepole and ponderosa pine stands of the northern Rocky Mountains has destroyed the overmature timber on millions of acres, in spite of strenuous efforts to control it. Such natural devastation is bound to occur among trees that have passed their normal life span. Expensive protective measures may delay it, but they can never make trees immortal. The primeval forest, though it is a self-perpetuating unit, is bound to go through cycles of deterioration and upbuilding.

Since deterioration is inevitable, and many years or even several centuries may elapse before the beauty of the primeval is restored, sustained-yield principles must be applied to primeval areas as well as to lands which are being logged. It is necessary, in other words, to maintain in a primitive state a complete rotation of age classes, so that when the overmature forest decays a mature stand will be growing up to take its place and a stand of reproduction will be advancing toward maturity.

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[11] A report upon the Effect of Excessive Tourist Travel on the California Redwood Park, E. P. Meinecke, 1928.

To illustrate this principle specifically, let us suppose that it is desired to set up a primeval rotation in the western white pine type. This type does not reach its finest development before 200 years. By 300 years the white pine elements of the stand begin to disintegrate rapidly. Thus the 200-year-old primeval stands which we set aside today at their most beautiful stage of development will be considerably less splendid in 2032. Consequently it is desirable to reserve mature stands of about 100 years which today lack much of the beauty of the older forests but in a century will have surpassed them in aesthetic value. Similarly it is desirable to set aside stands of present reproduction which will grow into the primeval forests of the twenty-second century.

In actual practice the first necessity is to preserve the virgin areas of the present. This action cannot be postponed. If many of the present overmature forests are not set aside as primeval areas within the next few years, they probably never will be set aside. The acquiring of the mature and immature age classes can safely wait in most cases, but sooner or later it will be desirable, in all except a few uniformly uneven-aged types, to make provision for preserving the important stages in the life cycle of the forest.

ADMINISTRATION

It will be well to consider briefly the different agencies which control forest land, to mention the theory under which their administration functions, and to point out which types of recreational land each ownership is adapted to handle.

NATIONAL PARKS

National parks are supposed to be confined to areas which remain essentially in their primitive condition, which are sufficiently inspirational to attract visitors from the entire country, and which are the finest samples in the United States of the particular types of natural phenomena which they exemplify. All commercial exploitation is barred. They are maintained as outdoor museums of the superlative and primeval. They are intended to serve chiefly as sources of inspiration, education, and aesthetic enjoyment, rather than as playgrounds, health resorts, or week-end camping sites. They include most of the superlative areas, are peculiarly well adapted for maintaining primeval areas, and owing to a recently formulated policy of keeping roads out of most of their territory they include splendid possibilities for wilderness areas.

NATIONAL MONUMENTS

The national-monument system of the United States is administered by the Departments of the Interior, Agriculture, and War. The number of monuments administered by each of these agencies is respectively 38, 16, and 24. The Agriculture Department monuments are included in national forests. The War Department monuments embrace barely 1 square mile altogether. National monuments administered by the Interior Department are of five classes: (1) Remains of prehistoric civilization, (2) historic relics, (3) geologic examples, (4) botanic reservations, and (5) wild-animal reservations. It is in the fourth class that forest recreational lands may well be administered. The Muir Woods near San Francisco and the Glacier Bay National Monument in Alaska are splendid forests preserved in national monuments from commercial exploitation. The national-monument system of the Interior Department is capable of taking over further primeval areas which it may be desirable to purchase, though on the whole the administration of such areas would seem to be more the function of the Forest Service.

NATIONAL FORESTS

The national forests are managed on the principle of providing "the greatest good to the greatest number in the long run." Under this policy the Forest Service recognizes that some lands are so valuable for recreation that no commercial exploitation should be permitted on them. Other lands are much more valuable for the timber, forage, and water power which they can produce, and on these lands recreation receives no consideration. On still a third sort of area some of the recreational values are safeguarded at the same time that the development of commodities is permitted.

In national-forest recreational development the stress is laid not on preserving the primeval but in providing healthy outdoor recreation. Camping, the development of health resorts, and general frolicking are encouraged. As a result national forests, in addition to providing some superlative areas and primeval areas, provide wilderness areas, camp grounds, residence areas, and outing areas for millions of people.

OTHER FEDERAL LANDS

Certain forest lands which could be used for recreation are found on the public domain, naval reservations, military national forests, and lighthouse reservations. The last three classes of lands embrace less than 60,000 acres. They can well continue under their present administration, with any recreational use they receive ranking distinctly secondary to their major purpose. Public-domain lands that are chiefly valuable for recreation should be turned over to the national parks, national monuments, national forests, or State parks, according to which type of management is best adapted to administering them. Provision has been made in the Recreation Act of June 14, 1926, for turning over to the States or minor political units public-domain lands of recreational value which seem better adapted to local than to Federal administration.

STATE PARKS OR FORESTS

State parks and State forests which may be devoted to recreation are supposed primarily to meet the recreational needs of the citizens of the State in which they lie. They should generally be distributed as evenly as possible throughout the State so that all the citizens may have a reasonable opportunity of enjoying their benefits. "They should be sufficiently distinctive and notable to interest people from comparatively distant parts of the State to visit and use them, not merely good enough to attract people from the region in which they are situated and merely because of the absence of more interesting areas within easy reach." [12]

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[12] Olmsted, California State Park Survey, California State Park Commission, 1929.

In most cases State parks will be under less stable control and more subject to political influences than Federal reservations. They will not, therefore, be so well adapted for the permanent retention of primeval areas, although the Adirondacks and California belie this generalization. They will usually be much smaller than Federal parks and forests, and consequently will seldom contain possible wilderness areas, although the Adirondacks again make a notable exception. Their chief value will be in supplying roadside, camp ground, residence, and outing areas for citizens of the States in which they lie.

COUNTY AND MUNICIPAL PARKS

In general the parks controlled by the minor civil divisions are meant for the ordinary outings of the local citizens. They will lack the sensational features which attract people from distant parts, but will make up for their constricted appeal by the intensive use to which they are put by those who live near them. They will be even more important than State forests for camp site, residence, and outing areas. Each municipality and county will have the responsibility of planning for the forest recreation of its own citizens, and the amount of land which each will have to supply will be in inverse ratio to the amount of Federal and State land in the vicinity.

PRIVATE LANDS

Private holdings are usually adapted only to those types of recreational land capable of yielding a profit. These are in general residence and camp-site areas. In competition with free or very cheap public camp grounds it is doubtful that many private camp grounds could pay, and certainly the various governments would not be justified in giving up this social service to their citizens simply to permit private operators to make a profit in this field. There are several privately owned wilderness areas in Maine and one in Georgia, but their preservation under this form of control is very perilous. One experiment is being broached in Maine for developing an outing area on private lands, the proceeds to come from toll roads, summer home sites, and concessionaires. The few large private estates and game reserves which still remain in the United States might also be classified as outing areas.

SUMMARY

In summary, the types of recreational area for which each of the principal forms of forest administration is especially adapted are:

National parks: Superlative, primeval, wilderness.
National monuments: Primeval.
National forests: Superlative, primeval, wilderness, roadside, camp site, residence, outing.
State parks and forests: Roadside, camp site, residence, outing.
County and municipal parks: Camp site, residence, outing.
Private: Camp site, residence.

FORESTRY AND RECREATION

Without the practice of forestry on the lands devoted to timber production, the best values of forest recreation would be doomed. For no matter how solemnly we may set aside in perpetuity lands on which timber may be neither "sold, removed, nor destroyed", the fact remains that if the need for timber becomes sufficiently acute the protected lands will be opened for exploitation. Men in general have always attended to their physical needs ahead of their aesthetic and recreational ones. Consequently, if our physical forest needs cannot be met on the areas devoted to commodity production, it is almost certain that the aesthetic and inspirational forest values will be sacrificed. But if the commodity forests are managed on a sustained-yield basis there will be no need to call on the recreational forests for wood products, and people may still continue to enjoy the adventure, the beauty, the inspiration, and the opportunity of communion with nature which the forest alone can supply.

AREA TO BE SET ASIDE FOR RECREATION

It will be impossible to make any precise calculations as to the area necessary to meet the country's forest recreational needs until some survey, much more thorough than anything yet attempted, has been made. However, the following estimates may have some validity as rough approximations.

SUPERLATIVE AREAS

It is generally agreed that all forest areas of superlative scenic value should be set aside exclusively for recreational use. The total of such areas in the United States probably does not amount to more than 3 million acres, of which over 2½ million acres have already been reserved for exclusive recreational use.

PRIMEVAL AREAS

An average of 150,000 acres of overmature forest would seem like a conservative estimate of the acreage to be set aside as primeval area in each of the 20 major forest types. The departures from this average in individual types will be wide, for much will depend on the availability of satisfactory stands. In addition to the 3 million acres of overmature forest which it is important to reserve immediately, it will eventually be desirable in all except a few uniformly uneven-aged types to set aside an equal area in both the mature and immature forest in order to have that succession of age classes which alone will insure the perpetuation of primeval areas. Furthermore, about 500,000 acres in minor forest types should be reserved, making primeval areas total about 9½ million acres.

WILDERNESS AREAS

Of the 20 million acres of forested land included in wilderness areas that have already been established or might be established, about 5 million acres in Maine are in private ownership. This land has practically all been cut over, and will no doubt continue to be handled for both commodity and recreational use. About 4 million acres of national forest wilderness will also be subjected to logging according to present plans. Approximately 1 million acres of the forested wilderness total is also superlative area. With these deductions there remains a total of 10 million acres of forest land which will probably be reserved primarily for wilderness recreational use. Some grazing will occur on much of this area.

ROADSIDE AREAS

It was estimated that a maximum of 100,000 miles of road leading through the forest should be protected by scenic strips on either side of the right of way. The width of these strips would range from 125 to 250 feet, with an average of perhaps 175 feet. Two strips 175 feet wide and 100,000 miles long would involve an area of approximately 4 million acres.

CAMP-SITE AREAS

It may reasonably be estimated that not more than one tenth of the American population is likely to go camping in the forest at one time, or in other words a maximum of 16½ million people out of an estimated stabilized population of 165 million. If the average area required by each camping party is about one third acre, and if, as the American Automobile Association has calculated, touring parties include an average of 3½ people each, each camper would require about one tenth of an acre. This would make the total camp-site area, in round numbers, 1½ million acres.

RESIDENCE AREAS

The acreage required for residence areas is even harder to estimate than for other recreational land. There were in 1930 about 30 million families in the United States. If the stabilized population of the country is one third greater than the present population, it may be expected that the number of families will increase by at least that ratio, making the stabilized figure not less than 40 million. It does not seem unreasonable to expect that one tenth of these families, or in other words, 4 million, will have forest residences. If the average area for each residence were 1 acre, the total area would amount to 4 million acres. In addition it seems reasonable to calculate at least 100,000 group camps, hotels, and resorts, with an average of 20 acres of forest for each, making an additional 2 million acres. Thus the total area required for residential use might be calculated very roughly as around 6 million acres.

OUTING AREAS

By far the larger share of those who make use of the forest for recreation do not demand the unusual qualities which characterize superlative, primeval, and wilderness acres. Their demands are satisfied by any land which retains a considerable growth of timber and has not been recently scarred by logging. Consequently, a goodly fraction of the forest recreationists can obtain the values they seek on any well-managed forest lands which have had sufficient time to recuperate from the effects of logging.

Theoretically, if the population of the United States were equally distributed, there would be no necessity for special outing areas. People might take their ordinary forest outings on lands which are being properly managed for the production of commodities. However, in the vicinity of certain centers of population the value of forest land for recreation may be so great that there will be no social justification for turning any of it over to commercial exploitation even for a few decades. Lumber is much cheaper to transport than people, and so it seems that wise land-use planning will favor exclusive recreational use of some at least of the land near areas where the population is particularly dense, leaving the more sparsely settled regions as the principal sources of commodities.

The total acreage of such outing areas as are needed for exclusive recreational use would only be a small fraction of the acreage of the well-managed forest land which might provide both recreation and commodity production. Nevertheless, it would probably amount to a good many million acres in the entire country. It seems conservative to estimate 10 or 12 million acres as the minimum territory which would meet the requirements for exclusive recreational outing areas. If, however, sustained yield forestry should not be practiced on the commercial forest areas, and recreational values on cut-over lands should be as seriously depleted in the future as they generally have been in the past, the 10 or 12 million acres would only meet an insignificant fraction of the total outing area requirements.

SUMMARY

These estimates, though admittedly crude, indicate that approximately 45,000,000 acres will be required primarily for recreational use. These acres will probably be distributed among the different types of recreational land about as follows:

	Millions of acres
Superlative areas	3
Primeval areas	9½
Wilderness areas	10
Roadside areas	4
Camp-site areas	1½
Residence areas	6
Outing areas	11
Total	45

It is well to point out that 45 million acres is only 9 percent of the total of 506 million acres of commercial timberland in the United States. Already 11 million acres have been withdrawn from timber use in national, State, and local parks. Of the remaining 34 million acres, at least 13 million acres are so remote and of such low productivity that it will undoubtedly be many years before they can possibly be considered for commercial exploitation.

The withdrawal of 45 million acres of land for recreational use would involve a very distinct economic benefit. It would concentrate the growing of timber for commodity use on a smaller acreage than is at present available, would consequently increase the value of commercial forest land, and would thus indirectly aid in making the commercial operation of timber lands more profitable.

WILD LIFE A FOREST RESOURCE

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BIRDS AND MAMMALS

By Paul H. Roberts, Administrative Officer, Branch of Research, and J. H. Stone, Junior Forester, Forest Service, in Cooperation with the Biological Survey

WILD LIFE DEPENDENT ON FOREST LANDS

Wild life since the mythical days of Robin Hood has been inseparably associated with the forests in song, story, and in fact. European history records the protection accorded the wild life of the forest that the nobility might have the full enjoyment of the chase. In some parts of Europe at the present time wild life is managed as one of the forest resources. The close association of the forests and game and the specific place given game as a forest resource in European forestry probably goes back to the time when game production was the primary purpose of the forest, and when foresters were in the main gamekeepers.

American history teems with accounts that show conclusively the importance of game as a food supply, as a source of clothing and many other materials needed in the everyday existence of our earlier civilization, and as a source of commercial return. Lacking this great resource of food and materials for livelihood and barter, the westward progress of the pioneers would unquestionably have been greatly retarded. Fur trading was one of the first, if not the first economic activity of the westward movement. The rich value contained in the pelts of fur animals was one of the important commercial attractions that drew the white man into the westward regions. Most species of these fur bearers thrived in the wooded areas.

As industry and agriculture advanced westward the natural ranges of wild life species were more and more restricted to the forest regions until today a great part of our wild life, with the exception of migratory wild fowl and certain upland game birds, is dependent on forest and wooded land in one form or another for all or part of its habitat.

Wild life, from the viewpoint of environment, may be divided into four general classes, viz: forest, range, farm, and water and marsh.

Much forest wild life requires large areas of woodland. In this class are included elk, moose, deer, bear, some species of grouse, turkeys, and some fur bearers and predators. Range wild life includes the plains animals, such as buffalo, antelope, jack rabbits, and some species of grouse and prairie chickens, which for the most part seek the open, and thrive there under natural conditions. Farm wild life includes small birds and mammals and such game species as pheasants, Hungarian partridges, quail, squirrels, and rabbits, which profit by the easily obtained food supply on farms and prefer areas where brush cover and open spaces occur. Migratory wild fowl mostly seek wild coastal lakes and marsh areas for resting places, food, and breeding grounds.

Although specific figures are not available, it is safe to state that the forested and wooded lands of the country provide all or part of the habitat for a major percentage of the remaining wild life, which for the purpose of this report includes birds and those mammals of importance for food, fur, hunting, and aesthetic qualities, and those commonly classed as predators.

The forest is a favorable natural habitat of wild life because, for most species, it furnishes three prime essentials: food, breeding grounds, and protection from enemies and the elements.

Forest and other wooded lands furnish these environmental conditions in whole or in part for all classes of game, fur bearers, and other wild life, except those that frequent the open country and unwooded marshes. In general, the topography and the flora of the wooded lands of mixed growth are most suitable to accommodate a great abundance and variety of animal life. Marginal areas are particularly favorable. Streams, lakes, wooded swamps, open marshes, ridges, and rough mountain areas afford a vast range of climatic conditions, varieties of food, and other factors of environment necessary for a great variety of dependent animal life. The forest mantle provides the cover needed for protection against natural enemies, and the increasing numbers of hunters.

Space limitations will permit the citation of only a few specific examples of forest requirements for wild life. H. L. Stoddard reports as a result of investigations in Georgia that in seed years pine mast is one of the chief foods of quail during the fall and early winter. Longleaf pine cones open rapidly and the seed falls within a 2-week period. Since it sprouts quickly, it furnishes food for only a short time. Loblolly pine cones open slowly and furnish a food supply well into the winter. Stoddard's investigations disclosed that in 1925 pine mast formed 32.5 percent of the quail food during the above period. The food supply is naturally affected by seed years and, when pine seed is not available, quail seek sweetgum seeds, acorns, or, as in the Central States, seeds of legumes which grow in woods, together with field weed seeds, corn, other grains, many wild fruits, and insects. In Northern States pine seeds are less important. Ruffed grouse derive a still larger part of their food from the forest. In addition to tree seeds, this species eats insects and a great variety of buds, leaves, and fruits.

Among the larger game, deer obtain practically all of their food from the forest. An examination of the deer range in Pennsylvania by experts from the United States Biological Survey and the State game commission disclosed that deer food consisted almost wholly of products of forest land. In the late fall in that State, they fatten on oak and beech mast. During winter they subsist on buds and twigs of most tree species. When food is scarce, especially during periods of heavy snowfall, they subsist largely on laurel or rhododendron and the inner bark of trees. In spring and summer and early fall they eat clover, vetches, weedy plants, berries, and fruits, and browse. Deer are largely species of the forest. They are traditionally a part of the forest, and their existence is dependent upon its presence.

Cover is essential to the existence of wild life. Aldo Leopold, a specialist in game management, in an article in the Journal of Forestry for October 1931, entitled "Game Range", says that all animals require from one to four types of cover in their environment. This is essential both for food and protection. Game species of low mobile powers, according to Leopold, prefer as their abiding place an area where various types of cover meet. For example, quail in the Central States are most frequently found where farm woodland and cultivated land adjoin. They require the forest cover for protection from natural enemies and a haven into which they can fly to escape from cats, snakes, and other ground enemies. Gradual reduction in cover by grazing farm woodland in the Central States and by removal of hedgerows and brush on the farms has been an important factor in the serious depletion of the quail in that section. Evidence of this importance of cover is shown by developments, as cited by Mr. Leopold in his Game Survey of the North Central States.

Forests and wooded lands have been obstacles over large areas to the encroachments of agricultural settlement, and have thus tended to preserve favorable environmental conditions for wild life, enabling many important species to persist in numbers, where in contrast many plains-dwelling species have been crowded out. Antelope, for example, which once thronged the feeding grounds and watering places of the Great Plains have been reduced to a mere fraction of their former numbers.

Although migratory water fowl, whose principal habitats are marsh and lake areas, are not directly dependent upon the forest, some species find food in forest mast, and further, the water supply for many of the marshes and lakes used by ducks and geese is dependent on maintenance of a forest cover on the headwaters of tributary streams. Thus the forest contributes in an essential way to their well-being.

PRESENT ECONOMIC AND SOCIAL WILD-LIFE VALUES

WILD-LIFE POPULATION

Reliable factual information regarding the full extent of our wild-life resource is sadly lacking. Many States do not have estimates of game population nor reliable figures of kill which might serve as a basis for calculations of population. A few States, where the importance of the game resource is recognized, have compiled considerable data on both population and kill. Such information for the most part pertains to the various species of deer, as these animals are doubtless the most widely distributed and most hunted big game species as well as those most commonly found in parks and preserves. In the West the Forest Service, in cooperation with the

Biological Survey and the State game departments in many States, has for many years made estimates of numbers of various species of game animals on the national forests and has compiled records of kill by species. The Biological Survey has also made independent counts and estimates of game animals in many localities. Such figures for game populations are, of course, estimates only. On the national forests they have, however, been kept for a sufficiently long period to indicate trends in game population.

Certain local situations requiring application of plans of game management have necessitated more detailed counts and estimates. Notable examples are the Jackson Hole elk herd, the Oregon-Nevada antelope herds, and the Kaibab deer. The accuracy of such estimates depends on the size of the areas concerned and the physical conditions obtaining in each locality. Such counts are of inestimable value, not only in the formulation of plans of management for the specific areas concerned but as indicators of game population and probable game forage requirements and capacity under other comparable environmental conditions. It should, however, be borne in mind that such counts or detailed estimates as have been made center around a few well-known species of game animals, principally deer, elk, antelope, and bear, and that nowhere is there to be found any reliable estimate of the existing numbers of small game, birds, or fur bearers, or in fact reliable statements as to what should be the population of such animals and birds or the extent to which they may be developed and perpetuated.

In general the data extant on the quantity and value of wild life give no more than an inkling of the astonishingly large and widespread importance of the resource. Lack of reliable nation-wide data is in itself sufficient to justify a systematic organized effort to obtain comprehensive information regarding our country's wild-life situation. Common sense demands that working plans not only for the development of this resource but for its coordination with broad plans embracing other forms of land utilization must be based on sound, fundamental facts.

Table 1 contains the estimates of big-game population on the national forests by States. The national forests of the Western United States comprise about 75 percent of the total western big-game range. It should again be borne in mind in considering this table that the numbers of animals shown are estimates only, and the figures represent comparative density of game by regions rather than actual densities. It has been demonstrated by experience, in cases where actual counts have been obtained for comparison with previously estimated numbers on the same area, that game estimates are in most instances materially less than actual numbers disclosed by counts. Consequently, the figures contained in the table are considered to be conservative.

Several interesting indications are to be found in table 1, showing the results to be expected in the development and use of the game resource, under a system which provides for multiple use of all forest resources. In the multiple-use management of the national forests game has for many years had a definite place, particularly in the West where there has been for the most part a close coordination of effort between State game departments, the Biological Survey, and the Forest Service. Some species of big game in the national forests of the West have increased definitely in numbers under this management. The high density of the Pacific-coast region is itself very much lower than that for California alone, where about 65 acres per big-game animal is the average for the State. In the East the figures are equally significant. In the South and Central regions, the acreage per head is high and this indicates the need for a study of the development of the game resource. In Pennsylvania, the sole representative of the Middle Atlantic region where game management has for some time been practiced, the density (chiefly due to the deer population) is nearly as great as that in California.

TABLE 1.—*Estimate of big-game animals on national forests by regions as of December 1931*

EASTERN STATES

Animal	New England [1]	Middle Atlantic [2]	Lake	Central [3]	South [4]	Total
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Bear, black	880	300	1,789	325	969	4,263
Deer	3,945	5,000	20,145	635	11,220	40,945
Elk		5	14		475	494
Moose	10		2,834			2,844
Mountain sheep		2				2
Total	4,835	5,307	24,782	960	12,664	48.548
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Area per animal [5] [7]	102	69	70	958	244	136

WESTERN STATES

Animal	Pacific Coast	North Rocky Mountain	South Rocky Mountain	Total	All United States, 1931	All United States, 1926
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Antelope	2,030	3,363	7,332	12,725	12,725	6,942
Bear, black	23,409	10,785	6,389	40,583	44,846	41,965
Bear, grizzly	13	526	208	747	747	814
Deer	418,485	118,535	315,765	852,785	893,730	613,750
Elk	19,719	24,485	52,181	96,385	96,879	82,478
Moose	3	2,044	2,444	4,491	7,335	5,142
Mountain goats	4,380	6,882		11,262	11,262	9,418
Mountain sheep	472	3,488	7,093	11,053	11,055	11,285
Total	468,511	170,108	391,412	1,030,031	1,078,579	771,794
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Area per animal [6] [7]	83	195	109	111	112	154

[1] Only New Hampshire represented.
[2] Only Pennsylvania represented.
[3] Nebraska, Tennessee, and West Virginia.
[4] Alabama, Arkansas, Florida, North Carolina, Oklahoma, and Virginia.
[5] Figures on net area.
[6] Figures on gross area forested land, antelope excluded.
[7] Areas as of June 1932.

SOCIAL VALUES

In Europe hunting was traditionally the sport of the nobility or of the privileged classes. The American ideal, in contrast to European tradition, is hunting for all who wish to enjoy it. There are several motives and reasons which underlie this traditional American conception of hunting.

The first Americans had to rely on wild game to fill the family larder. The pursuit and killing of game was a vital necessity, and skill in the use of firearms was the natural result. The skilled hunter, and the "crack shots", had a definite standing in the early American community life. The Thanksgiving turkey came from the wild—unmangled by poor marksmanship. These attributes of the hunter, when hunting was an essential factor of livelihood, have been transmitted more or less to succeeding generations as traditions of American life. They in part inspire the hunting urge today, which, however, is directed primarily for the purpose of sport.

Our early American stock lived in the country. It was essentially rural. The movement to the cities came with later industrial development. The man who moved from the rural district to the city retained the desire for the sport to which he was accustomed. He reverted to it when opportunity arose, and he in turn taught his sons to appreciate and enjoy it.

Additional leisure for the average man, through the seemingly inevitable shorter hours and fewer days of work, will add tremendously to the number of those who seek out-of-doors recreation. Hunting and fishing will attract large numbers of these folk. These sports have an attraction not akin to formalized recreation. Some kinds of hunting especially offer a means of satisfying the human urge for temporary return to the primitive. They offer variety. They demand virility, courage, and fortitude. They are a test of skill, and require arduous endeavor, wherever man pits his skill and endurance fairly against those of the game he pursues. Insofar as a return is made to original methods of hunting, the sporting aspect of hunting is improved and chances for survival of game are increased.

The human need for recreation is given detailed treatment in the section of this report entitled "The Forest for Recreation." Wild life in general affords enjoyment, the opportunity for building health and character, and for increasing scientific knowledge for all who care to pursue as well as for those who care only to observe.

The report of the Senate Committee on Conservation of Wild Life Resources (S.Rept. 1329), estimates that there was during the decade ending in 1930 a 400 percent increase in the numbers of people who enjoy the pastimes of hunting and fishing. The report also contains information collected by a representative of the Southern Newspaper Publishers Association, who, seeking to determine for purposes of publicity the relative news value of hunting and fishing as compared with baseball, football, golf, and tennis, assembled figures available for 14 Southern States. These showed that there were 4,420,876 hunters and fishermen in 1929 against a combined total of 4,916,652 for all other sports mentioned. The report estimates the number of licensed hunters in the United States in 1929 at 7,000,000, and the total of all hunters and fishermen as probably 13,000,000.

The maintenance of satisfactory hunting conditions in the face of so great a demand for hunting privileges will require more and more effective game and land management on all lands usable by game, in consistent relationship to other uses.

ECONOMIC VALUES

This discussion is concerned primarily with positive values of wild life as a whole rather than destructive tendencies of certain species that may require control in any effective wild life program. No attempt has been made to segregate the economic value of wild life on forest land alone, because of insufficient data. The available figures do show the great importance of the resource. In the past a great deal of thought and effort by biologists and other interested individuals and organizations has been devoted to wild life chiefly from the standpoint of preservation of species and the maintenance of hunting and fishing. Present-day problems of land management are turning the attention of land managers and economists to the present values and potentialities of this important land resource.

The financial burden on individuals and on the public arising from idle lands—principally those of marginal and submarginal agricultural character—and of depleted and devastated lands is constantly increasing. The alleviation of this condition requires that every resource capable of doing so must be made to yield a direct return. Forest wild life is capable of bearing a sizable share of the load. Direct values attributable to it are, (1) income from sale of hunting licenses and other fees, and (2) meat and fur values. Indirect values include, (1) receipts from the sale of hunting and fishing equipment by the manufacturers of arms, ammunition, fishing tackle, clothing, and other outdoor supplies; (2) expenditures of sportsmen for board, transportation, guide, and other local services; (3) annual expenditures of sportsmen and clubs, for hunting and fishing privileges on private lands; and (4) value of wild life, chiefly birds, as destroyers of insects preying on agricultural crops.

Table 2, the data for which has been prepared by W. L. McAtee and F. P. Callaghan, of the Biological Survey, records an annual income to the States of nearly $10,000,000 in 1930–31 from sale of hunting licenses alone. This represents less than 1 percent of the total annual value attributed to wild life. In many States this license income represents the total outlay of the State for game management and administration. It is that part of the direct annual income from game which is reinvested in the business. A few States supplement this income from the general fund, but, by and large, game management is at present chiefly self-supporting.

That the annual meat and fur value of game is considerable is reflected in the estimated total of more than $190,000,000 for the whole country, or nearly a fifth of the total annual value of wild life.

TABLE NO. 2.—*Estimate of the annual positive values of wild life*

HUMID AREA—EAST OF THE ONE HUNDREDTH MERIDIAN

State	Direct values			Recreational values			Total
	Meat and fur (14 cents a land acre)	Destruction of insects by birds (22.6 cents an acre)	Fish (44 cents an acre water surface)	Hunters' fees 1930–31 [1]	Spent by hunters ($25 each) [2]	Spent by tourists (13 cents an acre) [3]	
Alabama	$4, 594, 598	$8, 729, 736	$22, 879	$110, 530	$1, 989, 500	$4, 326, 233	$19, 773, 476
Arkansas	4, 706, 240	8, 941, 856	228, 096	78, 427	1, 599, 475	4, 437, 472	19, 991, 566
Connecticut	431, 872	820, 556	40, 832	[4] 115, 988	[5] 776, 525	413, 088	2, 598, 861
Delaware	176, 064	334, 521	114, 048	[4] 3, 390	[5] 44, 975	197, 184	870, 182
Florida	4, 915, 545	9, 339, 536	1, 071, 488	119, 644	1, 205, 900	4, 881, 011	21, 533, 124
Georgia	5, 261, 760	9, 997, 344	152, 064	85, 646	1, 204, 450	4, 930, 848	21, 632, 112
Illinois	5, 021, 452	9, 540, 760	175, 155	239, 489	7, 582, 525	4, 714, 528	27, 273, 909
Indiana	3, 229, 632	6, 136, 300	87, 014	279, 262	[5] 7, 619, 650	3, 024, 652	20, 376, 510
Iowa	4, 980, 505	9, 462, 960	157, 977	283, 073	[5] 6, 990, 725	4, 671, 430	26, 546, 670
Kansas	7, 326, 950	13, 921, 205	108, 134	[4] 131, 384	3, 265, 100	6, 835, 545	31, 588, 318

TABLE No. 2—*Estimate of the annual positive values of wild life*—Continued

State	Direct values			Recreational values			Total
	Meat and fur (14 cents a land acre)	Destruction of insects by birds (22.6 cents an acre)	Fish (44 cents an acre water surface)	Hunters' fees 1930–31 [1]	Spent by hunters ($25 each) [2]	Spent by tourists (13 cents an acre) [3]	
Kentucky	3, 600, 217	6, 840, 413	117, 427	74, 174	2, 122, 925	3, 364, 753	16, 119, 909
Louisiana	4, 068, 646	7, 730, 428	872, 115	102, 469	2, 394, 225	4, 035, 699	19, 203, 582
Maine	2, 703, 792	5, 137, 204	885, 632	113, 240	[5] 2, 806, 375	2, 748, 928	14, 395, 171
Maryland	890, 713	1, 692, 355	671, 897	115, 476	1, 552, 900	1, 025, 606	5, 948, 947
Massachusetts	720, 294	1, 368, 559	63, 923	291, 239	[5] 2, 851, 175	687, 731	5, 982, 921
Michigan	5, 150, 208	9, 785, 395	140, 800	[4] 646, 476	7, 582, 775	4, 823, 936	28, 129, 590
Minnesota	7, 244, 876	13, 765, 265	1, 076, 838	[4] 170, 052	4, 604, 225	7, 045, 542	33, 906, 798
Mississippi	4, 154, 035	7, 892, 666	141, 644	----------	----------	3, 899, 168	16, 087, 513
Missouri	6, 157, 939	11, 700, 084	195, 148	[4] 244, 088	[5] 4, 941, 900	5, 775, 744	29, 014, 903
Nebraska	6, 881, 996	13, 075, 793	200, 499	[4] 187, 509	[5] 4, 573, 975	9, 209, 408	34, 129, 180
New Hampshire	809, 177	1, 537, 437	87, 296	[4] 136, 214	[5] 1, 430, 300	777, 171	4, 777, 595
New Jersey	673, 254	1, 270, 183	199, 936	[4] 273, 004	[5] 4, 831, 300	684, 236	7, 931, 913
New York	4, 269, 798	8, 112, 616	436, 480	1, 108, 605	[5] 14, 523, 325	4, 093, 772	32, 544, 596
North Carolina	4, 367, 104	8, 297, 497	1, 037, 977	177, 100	2, 701, 250	4, 361, 843	20, 942, 771
North Dakota	6, 288, 396	11, 947, 953	184, 166	[4] 45, 721	659, 425	5, 893, 638	25, 019, 299
Ohio	2, 810, 304	5, 339, 577	84, 480	[4] 456, 583	11, 389, 725	3, 414, 528	23, 495, 197
Oklahoma	6, 219, 494	11, 817, 039	181, 068	92, 076	2, 248, 300	5, 828, 742	26, 386, 719
Pennsylvania	4, 016, 947	7, 632, 199	82, 790	[6] 1, 095, 025	13, 410, 025	3, 754, 483	29, 991, 469
Rhode Island	95, 603	181, 646	50, 969	[4] 19, 654	222, 625	103, 833	674, 330
South Carolina	2, 732, 352	5, 191, 468	139, 110	146, 706	2, 267, 850	2, 578, 284	13, 055, 770
South Dakota	6, 887, 372	13, 086, 008	210, 355	86, 320	1, 714, 600	6, 457, 568	28, 442, 223
Tennessee	3, 735, 155	7, 096, 794	94, 336	68, 088	1, 130, 325	3, 496, 230	15, 620, 928
Texas	23, 510, 860	44, 670, 635	985, 036	220, 516	2, 840, 800	22, 122, 547	94, 350, 394
Vermont	817, 510	1, 553, 269	123, 904	61, 451	[5] 1, 102, 050	795, 724	4, 453, 908
Virginia	3, 607, 475	6, 854, 202	665, 984	239, 777	[5] 3, 484, 650	3, 546, 566	18, 398, 654
West Virginia	2, 152, 371	4, 089, 505	41, 676	[4] 151, 448	[5] 2, 299, 050	2, 010, 944	10, 744, 994
Wisconsin	4, 950, 937	9, 406, 781	228, 098	157, 453	4, 293, 375	4, 664, 691	23, 701, 335
Total	160, 161, 443	304, 297, 745	11, 357, 271	7, 927, 297	136, 258, 275	155, 633, 306	775, 635, 337

ARID AREA—WEST OF THE ONE HUNDREDTH MERIDIAN

State	Direct values			Recreational values			Total
	Meat and fur (4 cents a land acre)	Destruction of insects by birds (13.3 cents an acre)	Fish (44 cents an acre water surface)	Hunters' fees 1930–31 [1]	Spent by hunters ($25 each) [2]	Spent by tourists (13 cents an acre) [3]	
Arizona	2, 913, 536	9, 687, 507	41, 113	[4] 75, 395	[5] 681, 725	9, 481, 139	22, 880, 415
California	3, 984, 691	13, 249, 098	236, 992	[4] 423, 718	5, 358, 550	12, 950, 246	36, 203, 295
Colorado	2, 653, 644	8, 823, 368	81, 664	218, 607	[5] 2, 521, 300	8, 648, 473	22, 947, 056
Idaho	2, 133, 862	7, 095, 092	150, 374	[4] 173, 446	[5] 2, 219, 500	6, 979, 481	18, 751, 755
Montana	3, 742, 745	12, 444, 629	224, 153	[4] 163, 122	[5] 2, 374, 575	12, 230, 150	31, 179, 374
Nevada	2, 811, 417	9, 347, 963	244, 710	[4] 15, 195	147, 975	9, 209, 408	21, 776, 668
New Mexico	3, 136, 076	10, 427, 455	36, 889	98, 541	[5] 534, 875	10, 203, 148	24, 436, 984
Oregon	2, 447, 539	8, 138, 067	307, 507	[4] 225, 981	[5] 1, 612, 525	8, 045, 356	20, 776, 975
Utah	2, 103, 910	6, 995, 502	790, 169	102, 428	[5] 1, 174, 050	7, 071, 168	18, 237, 227
Washington	1, 711, 001	5, 689, 080	645, 145	357, 286	[5] 5, 102, 125	5, 751, 366	19, 256, 003
Wyoming	2, 498, 406	8, 307, 201	90, 112	[4] 79, 051	[5] 577, 225	8, 146, 444	19, 698, 439
Total	30, 136, 827	100, 204, 962	2, 848, 828	1, 932, 770	22, 304, 425	98, 716, 379	256, 144, 191

TOTAL, ALL AREAS

United States	190, 298, 270	404, 502, 707	14, 206, 099	9, 860, 067	158, 562, 700	254, 349, 685	1,031,779,528

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[1] Includes amounts from combined hunting and fishing licenses but not from fishing only.

[2] Expenditures incident to hunting exclusive of license fees.

[3] Percentage of tourist expenditures attributed to attraction of wild life.

[4] Seasonal figures 1930–31.

[5] Based on combined hunting and fishing licenses plus hunting licenses.

[6] Returns cover period May 1, 1930, to Aug. 31, 1931.

That those who go in search of game contribute in many ways to business activity throughout the country is shown in the total returns of about $158,600,000 for hunters' expenditures and $254,300,000 of tourist expenditures credited to wild-life attraction. Hunters' expenditures include equipment, arms and ammunition purchases and in addition transportation, lodging, food, guide, and other personal expenses. Tourist expenditures are concerned with all of these but arms and ammunition purchases.

The Michigan Department of Conservation reported that hunters spend $5,000,000 for sundry items. The expenditure for gasoline was estimated at $500,000.

In Utah data on hunters' expenditures were obtained during a period of regulated deer hunting on the Beaver Ranger District of the Fishlake National Forest. Not including the hunters' time, the average cost per hunter amounted to $35.65. The total expenditures for 2,542 hunters amounted to $90,622.30. Only direct equipment costs, transportation, and supplies were included in these figures. They are believed to be quite typical for the State.

In addition, throughout the eastern regions, some private-land owners derive a substantial income from leasing their lands to hunting clubs or from selling hunting privileges to sportsmen. In the southern pinelands, Leopold states (Journal of Forestry, 28:321–326), the quail crop has an established market value for leasing purposes of 15 cents per acre per year. In his survey of the Central States, he says that in certain States of this region, preserves are leased for 10 to 15 cents per acre and toll charges of $1 to $5 per man-day are received. Such returns from a game crop, would be of tremendous assistance to the landowner in meeting carrying charges.

To the farmer, the dollars-and-cents value of wild life in destroying insects harmful to crops is very difficult to evaluate but without question is enormous. An idea of the value involved is given by W. L. McAtee's figure in table 2 of 22.6 cents per acre in the eastern region and 13.3 cents per acre in the western, or a total value for the United States of $404,502,707. This amounts to a substantial subsidy for the landowners of the United States.

The values shown in table 2 have been cited not as a strictly mathematical evaluation of the worth of our wild-life resource. They are estimates for greatly fluctuating values and no claims of great accuracy are made for them. But they do serve to indicate its present widespread economic importance as a direct land resource susceptible of expansion and development under wise multiple-use land management.

RELATIONSHIP OF WILD LIFE TO OTHER FOREST USES

Wild life is directly concerned with practically all other forest-land uses. To discuss all these relationships in detail in this report would involve the treatment of a great part of the field of plant and animal biology. It is desired to set forth only a few of the significant facts in which those concerned with forest and game management are becoming more and more interested, as the sciences of forestry and wild-life management develop with increasing knowledge.

TIMBER PRODUCTION AND UTILIZATION

In general it can be stated that those things necessary for the protection of the forest from fire, as well as the application of such measures as are necessary to keep forest land productive, contribute to the welfare of wild life.

The requirements of game, previously mentioned in connection with habitat, for various types of cover, are directly concerned with silvicultural methods used in cutting, slash disposal, and reforestation. Cutting operations open up the forest canopy and provide food and cover by encouraging the growth of low herbaceous and shrubby vegetation, and succulent sprouts highly relished by various wild-life species. On the other hand, game populations so increased may be expected to diminish gradually as the forests mature and food supply diminishes. Management must seek a proper balance based on the relative importance of each resource in the locality concerned.

For several years after unburned hardwoods are clean cut, sufficient food is available for deer but the shelter, except where mild climate prevails, is inadequate. Either advance growth should be available or maturing timber is needed to provide shelter.

Aldo Leopold, in the article in the Journal of Forestry already cited, asserts that in the layout of plantations, the effect of food and cover requirements on deer population should be considered. If the daily cruising radius of a deer is about 2 miles and the seasonal about 15 miles, the planting program should provide the different types of cover sought by them accordingly. His investigations of game in the Central States show that a bird supply on farm wood lots is dependent on the farmer leaving his brush on the ground and preventing destruction of undergrowth which furnishes cover for the birds.

The heavy deer population on forested lands in Pennsylvania has seriously affected certain forest areas, according to Henry E. Clepper in his bulletin entitled "The Deer Problem in Pennsylvania." He shows that protective measures resulted in an increase in numbers of deer in some sections to the extent that in their search for food they destroyed all advanced tree reproduction by browsing, and ate all foliage and twigs within their reach.

GRAZING OF DOMESTIC LIVESTOCK

Probably in no other phase of forest-land management is the interrelation of wild life production and other forest uses so apparent as in the use of the forest range by wild life and domestic livestock.

Measures adopted on the national forests during the past 20 years, resulting in an increase of grazing game animals, and requiring in many instances adjustments between game and domestic stock, have sharply focused the attention of foresters and game specialists upon the need for carefully planned and coordinated use of forest grazing areas.

The outstanding example is on the Kaibab Plateau where an area now comprising about 857,000 acres, was set aside in 1906 as a Federal game preserve, with deer the principal game species. A measure of protection was afforded by the operations of the United States Biological Survey up to 1923 in destroying predators, and conditions were made favorable for the deer in other ways. As a result, deer increased until the forage-producing capacity of the area was insufficient not only for the deer and domestic stock, but even for the deer alone. Notwithstanding a reduction of domestic livestock, to a point where competition with the deer was at a minimum, the continued increase in deer resulted in great damage to the more valuable forage plants and timber reproduction. By 1929 expert biologists estimated that it would take a minimum of 50 years under practically complete protection to restore the area to its original condition and that the productive capacity had been reduced to a degree which would sustain not more than 5 to 10 percent of the game which it was capable of supporting under proper conditions of normal use. Action has been under way for several years to remedy the situation and the excessive deer population has been reduced. Restoration of properly balanced wild life and vegetative conditions presents intricate problems of biological relationships and management.

There are many other places where action taken primarily for the purpose of game protection has brought results comparable with conditions on the Kaibab, and where the problem, from being one of game protection, has changed rapidly to many problems or a single interrelated problem involving game, livestock, recreation, timber, and other intricate phases of forest-land management.

The Jackson Hole elk herd in Wyoming is an example, known Nation-wide by foresters, biologists, sportsmen, and others interested in wild life, of the need for intensive research and the best obtainable knowledge and skill in solving problems of the relation of game to grazing land use.

Similar problems of concentration of game and its interrelation with domestic livestock grazing arise where grazing game animals are introduced into localities favorable to them. Elk plantings furnish examples of this nature. In 1913 a shipment of elk was made from the Jackson Hole herd to the Sitgreaves National Forest in Arizona. Seventy head of this shipment survived and were liberated in the locality south of Winslow, which had especially favorable environmental conditions. It was estimated in 1919 that there were 350 to 500 head of the animals. At the present time the estimate is over 5,000 head. During recent years damage has occurred to brush and tree growth along the streams. Unlike deer these animals are apparently constantly spreading to new range. The area is used by domestic sheep and cattle. The problem is one of working out the proper relationship, that each may be given its proper weight and place in the scheme of forest-land management applied on the area.

The relation between game animals and domestic livestock is not altogether concerned with particular conditions of concentration or competition between the two. Increasing knowledge of forage requirements for game, the plant species which they select and upon which they will thrive, as differentiated from the plant requirements of domestic livestock, offer excellent opportunities for determining a well-balanced relation between numbers of game and livestock, and of both to timber production under a system of correlated use of forest lands. Correction of current instances of improper balance is a matter of temporary concern. Satisfactory determination of permanent ratios, however, requires additional research and fact finding for a multitude of varying conditions and, in the final analysis, should afford the means of obtaining the best development and use of the game resource in its proper relation to timber and other lines of production. For example, the Forest Service, from information now available, believes that the present deer population on the national forests in Colorado, estimated at about 41,000 head, could, from the standpoint of forage requirements of both deer and livestock, be increased to approximately 150,000 without interference with livestock or timber production if additional winter range were made available outside the national forests. Similar increases of double the present numbers of deer and development of the wild-life resource are possible on other national forest areas.

Use of forest lands by wild life involves not alone the relationship between wild animals and domestic stock, but concerns also the proper balance between and interrelation of various classes of wild life. Experience in many places has amply demonstrated that the satisfactory status of the natural wild-life population may be disturbed by changes in food and cover conditions that favor one or more species over others, or by special measures provided for the protection of certain species from natural enemies or man. Here again the ultimate goal of land use is not the correction of what may be a temporary condition, but rather the application on a broad scale of principles that will result continuously in a smoothly flowing, properly balanced use for production of timber or other products and uses of forest land and of the various wild-life species which should be included in the objectives of wild life management on the area.

Competition between wild-life species may at times be a vital factor. In the southwestern part of the Sacramento Mountains in New Mexico, on the Lincoln National Forest, wild turkeys are very scarce. They have in fact nearly disappeared from that part of the mountains. On this particular range deer have increased on private holdings and adjacent national forest land to a point where they, together with domestic stock, have destroyed much of the more palatable shrubs and must turn to mast, i.e., acorns and juniper berries which they eat practically as soon as these fall from the trees. The use of the acorns and juniper berries by deer, together with reduction of other turkey feed through overgrazing, destroys the winter forage supply for turkey. In the north end of the Sacramento Mountains deer are not so plentiful and there are great numbers of turkeys.

An instance of competition between elk and deer has been noted on the Sitgreaves National Forest in Arizona, where a deer refuge is located within the elk range. Each winter the elk as they increase in number demand more of the forage along the south exposures of the canyons. In the winter of 1931 elk concentrated on one area, defoliating junipers to a height of about 8 or 9 feet and eating up other forage plants in proportion. Of the mule deer wintering on this range, 16 head were observed this spring (1932) in such poor condition that bones stood out all over their bodies. In the winter of 1931 and 1932 elk took practically all of the juniper within reach on several other areas within this refuge. If this herd of elk is allowed to continue to increase, it will be only a matter of time until it will exterminate the deer as the elk can reach higher and, therefore, can get food after none is left within reach of the deer.

Adequate discussion of the influence of predators in relation to a proper balance in nature by their repressive effect upon excess population of the smaller herbivores, such as mice, rabbits, and squirrels, which feed on forest vegetation, or to dwell on the effect of bird life in limiting destructive insects would require extended treatment. Briefly the relationship in the aggregate is of far-reaching importance in the fundamental management of forest lands.

WILD-LIFE MANAGEMENT

All of the relationships existing between game and other of the various products, uses, and services inherent in forest lands emphasize the extremely fundamental character of the problems confronted in obtaining satisfactory control and balance of the intricate and interrelated natural factors, and in the application of sound plans involving not only game but timber and all other products and uses of forest land.

DEVELOPMENT OF WILD-LIFE MANAGEMENT

Wild-life management as a phase of general multiple-use forest-land management, and especially with respect to game birds and animals, contemplates proper stocking of forest areas with game; removal of the surplus of either sex under proper procedure; the furnishing of suitable food and cover requirements for wild life; the regulation of protection from natural enemies and other injurious factors; fundamental research and fact finding; public education; and other measures that may be necessary to the welfare of wild life in a proper coordination with other products, uses, and services of forest lands. It contemplates the removal of the crop of game and fur bearers in accordance with the principle of sustained yield, which involves continuous production for human benefit, and yields the greatest economic and social return. Management requires cropping and utilization under plans providing for perpetuation and development of breeding stock.

The public mind has yet to be attuned to a full conception of the possibilities of wild-life management. Some people overlook the fact that protection alone may defeat its own purpose. Progress is being retarded even at present by those who are honestly loath to accept or cannot see the application of the principles of wild-life management even on areas where it is an obvious necessity.

This attitude or conception is due to inordinate depletion of wild life through reduced range and cover, lack of proper regulation of kill, and resultant threatened extinction of species and curtailment of suitable hunting. The disappearance of the passenger pigeon and the heath hen, of which there is now one remaining individual; the decimation of prairie chicken and wild duck; the reduction of the buffalo to the status of a park animal; the suppression of the antelope nearly to the last limits of survival—these well-known abuses have left, with lovers of wild life, as an almost indelible impression, the belief that the dominating action to check further depletion must be protection.

Protection was the underlying idea in the original conception of the game refuge, aside from special cases where the purpose was perpetuation of species or other special reasons. It was believed that if refuges could be established permanently that they would become breeding grounds from which game animals, as increases occurred, would drift to adjacent areas and supply such adjacent areas in number sufficient to provide good hunting.

The expected result has not occurred with certain important species. On the contrary, it has been demonstrated that deer especially are very local in their range, and that they will concentrate on their home range in the face of starvation rather than travel to areas a few miles distant where food is obtainable. Over a period of years, however, they will gradually extend their range. This characteristic of deer may limit locally the value of the refuge idea, and has resulted in overpopulation and in many instances in depleting the forage supply on the refuge. This accentuates the importance of having a system of management which will provide for a game supply on all forest lands susceptible to such use, except in cases where game or wild life of any given kind must be eliminated for specific reasons or for purposes not admitting of wild-life use.

The game policy of the American Game Association proposed at the seventeenth annual game conference in December 1930 was the first general presentation of a plan for systematic game management.

ADEQUACY OF PRESENT PROVISIONS FOR MANAGEMENT

As has already been indicated in the discussion of social and economic values of wild life, the present information as to wild-life populations and annual kill are fragmentary and inadequate. There is much fundamental biological research needed in regard to wild-life interrelationships, breeding and feeding habits of various animals, diseases, etc. German foresters recognize the value of such information. Their management plans as to regulation of kill are based on accurate game counts. The annual kill is carefully regulated, both quantitatively and qualitatively.

Such intensive management would not now be generally practical in this country, where we are concerned with vast areas of land in contrast to the small, intensively managed areas in the German forests. While conditions here are radically different from those in Germany, we also need definite and reliable information regarding our wild life resource upon which to base sound management.

Table 3 shows the distribution of the land upon which wild life abides, according to ownership or control, whether in Federal, State, county, municipal, or private. This diversification of ownership of land by individuals and Federal and municipal governments, coupled with the fact that the 48 different States, with widely varying legislation regarding wild life, claim regulatory power over the wild life within their boundaries, obviously results in a complicated situation having endless ramifications affecting national or local aspects of wild-life management.

TABLE 3.—*Areas forest land usable for game management, by type of ownership and region*

Region	Federal	State, county, and municipal	Private		Total	Lands owned or leased by States for public shooting grounds[1]
			Farm woodland	Other		
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
New England	544, 000	852, 000	6, 400, 000	19, 638, 000	27, 434, 000	375, 000
Middle Atlantic	366, 000	4, 299, 000	8, 693, 000	16, 412, 000	29, 770, 000	4, 101, 000
Lake States	3, 534, 000	4, 899, 000	14, 244, 000	37, 668, 000	60, 345, 000	4, 269, 000
Central	799, 000	327, 000	33, 438, 000	31, 495, 000	66, 059, 000	143, 000
South	3, 899, 000	535, 000	69, 750, 000	142, 684, 000	216, 868, 000	246, 000
Eastern United States	9, 142, 000	10, 912, 000	132, 525, 000	247, 897, 000	400, 476, 000	9, 134, 000
Pacific coast	41, 158, 000	1, 916, 000	9, 499, 000	28, 722, 000	81, 295, 000	----------
North Rocky Mountain	33, 059, 000	1, 404, 000	2, 680, 000	6, 044, 000	43, 187, 000	----------
South Rocky Mountain	69, 362, 000	3, 248, 000	5, 242, 000	11, 748, 000	89, 600, 000	----------
Western United States	143. 579, 000	6, 568, 000	17, 421, 000	46, 514, 000	214, 082, 000	----------
Total United States	152, 721, 000	17, 480, 000	149, 946, 000	294, 411, 000	614, 558, 000	9, 134, 000

[1] Figures probably very incomplete.

For example, the Forest Service's administration of national forests in 31 States of the Union embraces an area of approximately 140 million acres, not all of which, however, is forested. The net forested area of the national forests is approximately 108 million acres. The regional administrative units of the Forest Service cover all or parts of two or more States. The Forest Service then is in the position of being responsible for the administration and protection of large areas of land involving the proper management of wild life, together with timber and other resources, without having direct control of game except as a final recourse for protection of the land and other resources.

Not only does the Forest Service not have use or control of this wild-life resource, but administrative plans that it develops and which tie in with wild-life management must be shaped and fitted to meet in some degree requirements of State game departments and State legislation. This situation may affect vital administrative measures.

Certain States have ceded the authority to the United States to administer the game on national-forest lands. Georgia, by act approved August 15, 1922; North Carolina, by act approved March 9, 1915; and Tennessee, by act of March 28, 1917, consented to the making by the Congress of the United States or under its authority of all such rules and regulations as the Federal Government shall determine to be needful in respect to game animals, game and nongame birds, and fish in such lands as shall have been, or may hereafter be, purchased by the United States under act of March 1, 1911.

Arkansas, by act of February 9, 1925, consented to the same Federal control of game animals, game and nongame birds, and fish as in the above instances, but limited it to specific counties.

Some States have recognized the value of game to the private landowner and have enacted laws encouraging game management and allowing the private landowner to share in its benefits. Various plans are now being tried out. The "Texas shooting preserve statute" requires the landowner wishing to sell or lease shooting on his land to purchase a license which is renewable on condition that the licensee has enforced laws and kept a record of hunters and kill. State protection against trespassers is not extended to those charging over 25 cents per acre or $4 per man-day. The Michigan "shooting preserve statute" authorizes on licensed preserves a regulated pheasant kill under a special long season. To qualify under this privilege the owner must release twice the proposed kill under warden supervision and operate the preserve satisfactorily. Under the Williamston plan operating in Ingraham County, Williamston Township, Mich., the farmers pool their land resource and issue tickets to members, who may dispose of them as they see fit. The number of tickets to each family represents the number of hunters his land can carry simultaneously. Under the Pennsylvania plan the State leases auxiliary refuges at a nominal rate, and the owners of immediately adjacent land agree to allow public hunting with permission in consideration of State patrol, State restocking, and laws regulating conduct of hunters. Indiana has enacted a tax law of fundamental importance to game, particularly quail. This law encourages the development of ungrazed woodland and extends to registered woodland a flat valuation of $1 per acre, against which the usual current local tax rate is applied. There is no yield tax, but the owner must agree not to pasture and must have the area surveyed. These isolated cases indicate the growing appreciation of the value of the wild-life resource and the need for its perpetuation and management.

THE PISGAH NATIONAL GAME PRESERVE MANAGEMENT PLAN

The important requirements of game management have been embodied in the plans of the United States Forest Service for the Pisgah National Game Preserve. The important facts and features of this plan are as follows:

The preserve was created by proclamation of President Wilson, October 17, 1916, on lands which the Government had acquired in January 1915 under the Weeks law from the Vanderbilt Estate. The number of deer on the 98,513 acres now in the preserve was probably less than 1,000 at the time it was established.

In order that the Federal Government might assume sole control of game, the State of North Carolina on March 9, 1915, ceded to the Federal Government the authority to make and administer rules and regulations relative to game, birds, and fish, and Congress on August 11, 1916 (39 Stat. 476), authorized the President to designate areas that should be set aside for the protection of game animals, birds, and fish and provided a penalty for trespass. From January 1915 to October 17, 1916, the acquired lands now forming a portion of the Pisgah National Game Preserve were open to public hunting, and shortly after the preserve was established trespass was bold and frequent. By 1919 law enforcement was very active, and the turning point in trespass came about 1922. The game census for this area shows an increase in deer from 1,000 in 1916 to 5,500 in 1931. The game-management plan states:

> Outstanding values as to natural resources of timber, water, and soil, characterize the Pisgah district of the national forest of the same name. The wild-life resources and their management and development are an integral unit of the successful administration of the forest and preserve, which are coextensive. This fact makes it imperative that the wild-life plan be closely harmonized with other plans and objectives. Fortunately, this may be readily accomplished with few compromises.

Briefly, the plan involves stocking depleted game areas; removal of the surplus of any species of either sex on a definite area under an established procedure that includes transfer of live animals to other areas for restocking and hunting; the proper determination of boundaries of the hunting area, seasons, and bag limits; the improvement and maintenance of the capacity of the area to produce forage; intensive studies of the wild life on the preserve in all its aspects; and education of the public from many angles for the purpose of eliminating influences adverse to game management.

This plan contemplates the minimum disturbance of wild life and seeks to preserve a proper balance between the plant life and animal population. The underlying idea is to apply the weight of corrective measures so that desirable species may be favored, as, for example, by the control but not the extermination of predators. The desirable species are to be maintained at the maximum reproductive capacity by removal so far as possible of the less desirable individuals. The natural fauna is considered adequate in point of variety and abundance to furnish the stocking required.

The plan of wild-life management for the Pisgah National Game Preserve is probably one of the most forward-looking game plans in this country. It embodies many of the essential features of good conservation practice, such as unity of control, the principle of sustained yield, and correlated multiple-use forest-land management.

WILD-LIFE SUPPLY

Table 1, allowing for considerable variation in estimates, indicates wide differences in game supply by broad regions of the United States. Certain species of wild life are unquestionably increasing in an appreciable degree and over considerable areas. The estimated increase in numbers of game animals on the national forests during the period 1926–31, for example, is 40 percent. This increase can be attributed primarily to the practice of good land management over a long period, which has provided the variety of food, cover, and protection essential for game welfare. Better regulation of hunting is provided through the cooperation of the State game departments and the Forest Service than can be afforded to areas of diverse ownership. Many States do not have the finances to provide adequate regulation when such regulation is dependent entirely on State patrol. Another important factor in the management of national forest lands is the technical research, advice, and assistance provided by the Biological Survey.

Outside of the national forests in several States certain species of game are increasing where conditions have been made favorable for them, and regulation has been applied. Elsewhere, and in general, game has without question decreased and is still decreasing on much of the forested area of the country. There are numerous reasons for this condition. Increase of hunters is one. The statement in the report of the Senate Committee on Conservation of Wild Life Resources which notes a 400 percent increase in hunters and fishermen in the decade ending in 1930 has been previously cited. Greater mobility of hunters who, first by automobile and lately by air, can travel great distances to obtain their favorite form of sport, lack of adequate control of hunting, fire, and disease have all played their part. Moreover, notwithstanding the inroads upon game supplies from the above causes, deterioration and destruction of food and cover and other right enrivonmental conditions of habitat have been important factors in still further reducing the numbers of game. Reduction in quail in the Central States and other eastern regions is due in large measure to removal of quail cover by clean farming operations and woodland grazing, according to Aldo Leopold. In this region agriculturists have exhorted the farmer to clean up his farm, brush, and fences, plow up hedgerows, and clear away brush from farm woodlands. This has effectively reduced the quail and grouse population on farms.

Quail in the San Joaquin Valley region of California are generally decreasing in numbers, and the area over which they occur in sufficient abundance is rapidly narrowing, according to men who have observed conditions for many years. This decline in numbers and range is directly attributable to deterioration of habitat. Quail formerly inhabited the valley in great numbers, and the finest part of their habitat was in the brushy foothill regions where there was abundant food and cover. Overgrazing of these foothill areas has destroyed much of the herbaceous vegetation and low shrubs that furnished not only cover but also quail food. Good land management, restoring the productive capacity of the land for grazing of livestock, would coincidentally restore the conditions favorable to quail.

Good wild-life management on forest lands in the ultimate analysis is simply one phase of good multiple-purpose forest land management, which seeks for the highest quality and quantity output of products, uses, and services. In general the practices that contribute to the perpetuation and development of other products, services, and uses may be made to contribute to the welfare of wild life.

FOREST LAND USED BY GAME

Recent estimates by the Forest Service place the total forest-land area of the United States, in round numbers, at 615 million acres, variously distributed by region and ownership, as already shown in table 3.

FEDERALLY OWNED OR CONTROLLED

The Federal Government owns, or controls, in round numbers, 153 million acres of forest land, or approximately 25 percent of the total area of forest lands in the United States. In the three western regions the Federal Government's share is 67 percent of the total forest land in the West. In the eastern regions the Federal share of forest land is only 2 percent. The importance of these figures lies in the fact that Federally owned forest lands, particularly the national forests and the national parks and monuments, in general constitute the largest and most consolidated areas susceptible of wild-life management, particularly in the West.

Of the Federal area, national forests embrace 107,773,000 acres, or 70 percent; national parks and monuments, 4,420,000 acres, or 3 percent; and the remaining 40,528,000 acres, or 27 percent, is made up of Indian reservations, public domain, and other lands. All of these areas comprise large acreages of protection forest where the forest growth is mainly woodland and chaparral. On the public domain there is no administration of game except such as may be done by the States. Indian reservations, generally speaking, are susceptible of game management. However, on some reservations peopled by primitive Indians, game and fish constitute a relatively important source of food supply to these Indians, whose right to continue to hunt and fish at all times as they have been accustomed to for generations has been guaranteed under treaty provisions. It is understood that as Indians increasingly adopt the white man's practices they do not rely on game for food so much as formerly. In the western regions, 26,311,000 acres are in game refuges, Federal game preserves, and other areas wholly or partially closed to hunting.

These great acreages of Federal forest land, most of which is well consolidated in extensive tracts, offer the very finest opportunity in the country for the development of the wild-life resources for public benefit. The environmental conditions for game and other wild life are of the best. All of this land except the public domain areas is under management for one purpose or another, some of it with the primary objective of wild-life conservation. Where the timber resource is a principal objective, such management in the main is beneficial to the welfare of wild life. In the national parks wild life is one of the important attractions. The development of the wild-life resource on all of these Federal lands, including parts of the public domain in its proper relation to other resources and use values, will add materially to the public benefits, social, as well as economic, derived from their management.

STATE, COUNTY, AND MUNICIPAL OWNERSHIP

The nearly 17½ million acres of State, county, and municipal forest lands amounting to 3 percent of the total forest area, of which roundly 11 million acres is in the Eastern and 6½ million in the Western United States, include many areas used especially for wild-life purposes, and most of the areas utilized for wild life in parks and zoological gardens. In the Middle Atlantic and Lake regions they include large areas of public shooting grounds.

Although comprising only a small percentage of the total forest land area of the country, these areas afford probably the best opportunity, particularly through State forests and parks, for the proper coordinated development of wild-life values. This is especially the case in the East where most of the forest lands are in private ownership, and the management of wild life is thereby a much more complicated problem.

With the increase in area of these lands, owing to reversion of tax-delinquent lands and other forms of State acquisition, the development of the wild-life resource under coordinated multiple-use management will have great possibilities in alleviating the financial burden that such lands entail and in furnishing other public benefits that are afforded by wild life.

PRIVATE OWNERSHIP

Of the privately owned forest land amounting to about 444 million acres, the large acreage in farm woodlands in the Eastern United States, and more especially in the Lake, Central, Middle Atlantic, and South regions (table 3), is particularly significant in relation to the management of small game species such as quail, certain species of grouse, pheasants, and rabbits—the last mentioned of which furnishes shooting, according to the Biological Survey, for by far the majority of the hunters of the United States. Again, the large areas of farm woodland are in the Eastern United States, the area of the greatest concentration of population. Because of their general distribution, these lands to a great degree furnish the forest-land part of the game habitat for these regions. Other lands in private ownership not classifiable as farm woodlands play their part in the same manner, but are probably not as important in this respect because they are not of such general distribution, and because they contain considerable acreages of more or less unbroken timber or woodland, more suceptible of use by big game. Such privately owned lands contain areas available for lease and management by individuals and clubs as private hunting preserves.

Here again recognition of wild-life values and their development under coordinated multiple use land management may be made to ease the financial burden of the private owner and provide other public wild-life benefits. A happy circumstance also is that good management of the woodland and timber resources will contribute in great degree to the welfare of wild life.

FOREST LAND WHOLLY OR PARTIALLY CLOSED TO HUNTING

Table 4 presents a classification by ownership of Federal forest-land area wholly or partially closed to hunting. These areas, according to the available information, amount to about 29 million acres, or 5 percent of the total forest-land area of the United States. This acreage includes some of the especially valuable game and wild-life breeding grounds of the country, many areas suitable for fundamental research and for obtaining basic facts regarding wild life, areas devoted in part to the aesthetic values of wild life in its natural habitat (notably the national parks and monuments). In addition to the Federal lands, there is an indeterminate acreage of State, county, and municipal forest land which would fall in the same category and which would amount to several million acres.

TABLE 4.—*Area of public forest land wholly or partially closed to hunting* [1]

Region	National-forest land			National parks and monuments	Total
	State refuges [2]	Federal game preserves [3]	Game areas by administrative restrictions		
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
New England	8,000			12,000	20,000
Middle Atlantic	18,000				18,000
Lake States	837,000	3,000			840,000
Central	224,000	30,000		111,000	365,000
South	371,000	269,000		110,000	750,000
Eastern United States	1,458,000	302,000		233,000	1,993,000
Pacific coast	5,107,000	21,000	234,000	1,122,000	6,484,000
North Rocky Mountain	4,165,000		2,192,000	898,000	7,255,000
South Rocky Mountain	9,968,000	909,000	625,000	2,167,000	13,669,000
Western United States	19,240,000	930,000	3,051,000	4,187,000	27,408,000
Total, United States	20,698,000	1,232,000	3,051,000	4,420,000	29,401,000

[1] Areas given, particularly in West, include some nonforest land. These figures represent the best estimates obtainable from available information.

[2] There are some State game refuges on forest lands on the public domain for which definite figures are not available.

[3] Some areas included here open to regulated hunting.

NOTE.—There are some areas of Federal game preserves on forest land not within the national forests or parks for which figures are not available.

The areas in this table represent forest lands so far as data were available, where special measures have been adopted for game protection and management by the Federal Government, and where hunting in some cases may be allowed to meet management requirements. Areas in national parks and monuments, migratory bird refuges, and other Federal wild-life areas, where hunting is prohibited, are also included.

Some areas of nonforest lands are included, in the West particularly, where sufficient data were not available to afford a satisfactory segregation. The percentage of this nonforested land is, however, so low that it will not materially affect the totals. The figures exclude, as far as data were available, water areas within the forest areas. No attempt has been made to include private lands posted against hunting, because the actual hunting status of such lands is indefinite; they are often hunted by the owner or others to whom he may extend or sell the privilege. The column "Game areas by administrative restriction" in table 4 includes national-forest lands closed to the grazing of domestic livestock.

The areas in State refuges on national-forest lands are transitional only. In several States some of the areas listed are subject to opening for hunting when conditions justify such action and areas that are now open are subject to restrictions on hunting.

The division of this whole area between the western regions (93 percent) and the eastern regions (7 percent) is in contrast with the distribution of total areas of forest land shown in table 3, where some 65 percent of the 615 million acres of forest-land area of the United States is attributed to the eastern regions. The 27 million acres closed to hunting in the western regions is 13 percent of the total forested land area of these regions, whereas in the East the area closed to hunting is less than 1 percent of the total forested area.

PUBLIC SHOOTING GROUNDS

The ideal and traditional conception of the public shooting ground idea is shooting for all who desire it for sport or other social reasons. Much of the social benefit to be derived from wild life, particularly for the rank and file of the hunting public, is dependent on maintaining large areas of land available for this purpose.

With the passing of public lands into private ownership, especially in the East, the land open to public shooting has become more and more restricted. In many sections of the East the situation is acute and involves all species of game animals. Privately owned lands are often posted against hunting. Many areas are leased by individuals or clubs for exclusive use. Hunting grounds for the ordinary hunter who cannot afford to pay high charges are very limited in many localities.

Several States in the eastern United States, because of the restricted conditions, have taken measures to relieve this situation and are establishing areas for use as public hunting grounds. Table 3 shows the area acquired or made available for this purpose. Considerable progress has been made in the Middle Atlantic and Lake Regions, each having in excess of 4 million acres.

Publicly owned or controlled lands must in the main afford areas available for public shooting grounds. The combined acreage of Federal, State, county, and municipal forest lands in the eastern United States is about 20 million acres, but a considerable part of this acreage, however, is in State, Federal, county, and municipal parks or other areas not usable for public shooting. Altogether there is probably less than 10 million acres of public-owned forest land in the East available for this purpose. This acreage will doubtless be increased as time goes on by reversion of tax-delinquent forest areas and by acquisition for National and State forests or for wild life and other purposes.

Forest land in the West under Federal, State, county, and municipal ownership or control now approximates 150 million acres, out of a total forested area of 214 million acres. This should be ample to take care of the demands for public shooting grounds for big-game species in Western States. A shortage of public shooting grounds in some localities is, however, felt with respect to migratory waterfowl and quail. The situation as regards quail has developed from the depletion caused by overgrazing on public domain and other areas, and a considerable part of the remaining good quail shooting is restricted to private lands. This situation is felt particularly during the low period of the quail-population cycle. The need for public shooting grounds for these upland birds in the West can probably be very adequately met by (1) consolidation and administration of public domain areas, (2) the use of areas recommended for addition to the national forests from the public domain for watershed protection and other purposes, and (3) by development of the game resource on these lands.

The land area available for public shooting will probably never exceed the requirements of the hunting public. Plans for wild life and forest land management should provide the maximum available area for this purpose.

In general, all forest land is susceptible of use by one or more wild-life species having economic or social value. The acreage of forest lands so used must be dependent on the importance attributed to wild life in making an evaluation of land resources as a basis for sound multiple-purpose forest-land management. Without doubt, wild life has sufficient values to be accorded a place in good land utilization on most of the total forested area and has minimum values only in exceptional situations where peculiar local conditions direct management toward special objectives which eliminate the wild life return or reduce it to an inconsiderable amount.

FISHERY MANAGEMENT IN FOREST WATERS OF THE UNITED STATES

By Henry O'Malley, Commissioner of Fisheries

The forested areas of the United States, including public lands under the control of the National Forest and Park Services as well as those privately owned, constitute the most favorable habitat of many of our valuable game fishes as well as the habitat during early life of some of the commercial anadromous fishes such as the salmon and shad. A complete program of forest management, therefore, logically includes a plan for managing the supplies of fish found therein for the public good, assuring not only perpetuation of the supply for the benefit of future generations but wise husbandry permitting development of potential supplies and their fullest use for the benefit of the present.

In the following pages is presented a discussion of the place of modern fish husbandry in the larger program of forest management, prepared in response to a congressional resolution, in which is considered the influence of forests on fish life, the economic and social values of fish in forest waters, present methods available for adequately managing the fishery resources in the public interest, and the means of carrying into effect such a program in forest areas.

INFLUENCE OF FORESTS ON FISH LIFE

That forests have a profound effect on fish and other aquatic life must be evident to even the most casual observer. This influence is far-reaching and affects almost every phase of the life and activities of these animals. In streams, the growth and well-being of fish are affected by the temperature of the water, the speed of the current, the presence or absence of food, the nature of the bottom, the amount of shade and shelter provided by the vegetation on the banks and in the water, and by variations in the water level. In lakes and ponds the relative extent of deep and shallow water is also an important factor.

One of the most obvious effects of forests on stream conditions is in connection with the temperature. Forests tend to keep cool the stratum of air overlying the water and prevent the stream bed and surrounding ground from warming during the day. The result is that in forested regions the temperature of the water is usually considerably lower than in streams exposed to the full force of the sun's rays. Not only is the average temperature lower but the daily fluctuations are much less. The cooling effect of the forest is so pronounced that we have numerous instances of streams in which the temperature is lowered several degrees as a result of flowing through a forested area.

The influence of the temperature on fish is most noticeable in the case of trout, which are classed as cold-water fishes as distinguished from such game fishes as bass or sunfish, which require warmer water. The eastern brook trout thrives best at temperatures between 50° and 60° F. but may for short periods withstand temperatures as high as 75° F. when the water is well aerated. Under similar conditions rainbow and brown trout can survive temperatures of 80° F., and possibly even higher, without apparent injury. This means that in forested areas many streams are suited to trout which if fully exposed to the sun would be uninhabitable by these fish. In many localities as a result of deforestation streams which formerly provided ideal conditions for trout are now unable to support these fish. Others have become too warm for brook trout, which formerly were present in great abundance, but are still suitable for brown or rainbow trout.

Forests usually exert a favorable influence on the supply of food available for fish, but in some instances they may have an opposite effect. As in the case of land animals, fish are, in the last analysis, dependent on plants—especially the algæ—for most of their food. When the trees and shrubs on the banks of a stream are crowded closely together the shade may be so dense as to seriously interfere with the growth of plant life in the water. This, of course, results in a marked scarcity of animals, and we frequently find such areas to be almost devoid of fish. Occasionally dead leaves may accumulate to such an extent in pools and quiet streams as to seriously interfere with the growth of food organisms.

In most cases, however, the effect of forests on the production of fish food is distinctly beneficial. Fallen trees in the bed of a stream or along the shores of a lake furnish support for insects and other aquatic organisms which can usually be found in such places in large numbers. They also provide an ideal shelter for fish. Trout delight to lurk in the cool depths of pools containing fallen logs and branches beneath which they can retreat from their enemies. The importance of shelter in the daily life of fish is frequently not realized, and yet even a casual investigation will show that ordinarily very few fish are to be found where there are no hiding places near by, even though other conditions may be favorable. This is especially true of trout and bass, and every experienced angler knows that there is no better place to cast for these fish than near an old log or a tangle of submerged branches.

Food and shelter are largely dependent on a stable environment, and there is probably no way in which the forests exert a more profound effect on fish life than in regulating the run-off thus producing a regularity and permanency in lakes and streams not usually found in nonforested regions. It is well known that streams with a gentle current and no great or sudden fluctuations in level have a much richer fauna and flora than torrential streams subject to violent floods. These floods scour out the stream beds and either carry off or destroy great quantities of aquatic organisms. In some instances fish may be killed in considerable numbers, but it is believed that ordinarily it is the invertebrates on which fish feed that suffer the greatest injury.

Following the unprecedented floods in Vermont several years ago, it was found that the streams still contained large numbers of trout but that insects and other invertebrates on which trout feed were very scarce, and for months the fish showed every indication of partial starvation. Severe floods may also destroy the spawning beds and any eggs or fry which happen to be present.

Extensive fluctuations in the water level also result in large numbers of aquatic organisms being left behind and destroyed as the waters recede. Not infrequently fish, especially the younger stages, become stranded in small pools which eventually dry up or become too stagnant for their support. The evil effects of rapidly fluctuating water levels are especially noticeable in the case of hydroelectric developments. In most instances the construction of reservoirs for power purposes would be distinctly beneficial to fish if it were not for the great fluctuations in water levels which are not only destructive to the food but frequently expose the eggs and fry of fish to the effects of wind and sun.

Floods and erosion go hand in hand and the resultant deposits of silt frequently do immense injury to fish life either directly or indirectly. The extent to which fish are directly injured by the presence of large quantities of silt depends largely on other conditions in the water and also on the species of fish concerned. Some species such as catfish and carp are apparently but little affected by roily water, but trout, bass, and other game fishes undoubtedly thrive best in waters containing little silt.

The greatest damage to fish from the presence of silt is undoubtedly indirect. The deposition of large quantities of sediment in a lake or in the bed of a stream destroys great numbers of food organisms and it is not infrequent to find areas which were once rich in food now changed to wastes of barren sand. In fact, there is no type of bottom which produces less food than the shifting sands which are now becoming so common in our streams and lakes as a result of deforestation and cultivation. Vegetation is buried or prevented from obtaining a foothold and pools which once furnished food and shelter become filled and the fish driven elsewhere.

The mere presence of silt in the water has a decidedly detrimental effect on the smaller plants and animals. It has an especially disastrous effect on the plankton which in lakes and quiet streams forms such a large part of the basic fish food. Deposits of this material also form a thin but continuous layer over all objects on the bottom which smothers the smaller organisms and frequently kills large numbers of fish eggs.

In view of these facts there can be no question that the tendency in some quarters to lay all the blame for the scarcity of fish in our waters on overfishing is far from justified. That overfishing is largely responsible is evident, but in all fairness we must concede that the removal of forests and other cover that have such an important function in reducing floods and erosion have had an important part in producing the deplorable conditions we find today.

In order to obtain a proper appreciation of the importance of forests in connection with the production of food and game fishes, it is necessary to consider in some detail the extent and value of waters in forested areas suitable for fish.

ECONOMIC AND SOCIAL VALUES OF FISH IN FOREST WATERS

EXTENT OF STREAMS AND LAKES SUITABLE FOR GAME AND FOOD FISHES

There is no inclusive or complete tabulation of the mileage or acreage of streams and lakes suitable for game and food fishes covering the Nation as a whole. The only data are fragmentary, covering a single State, or, in most cases, limited portions of a single State, or certain specified areas such as the national forests. It is immediately evident that the Great Lakes and other large lakes, as well as the larger river systems such as the Columbia, Colorado, Rio Grande, Mississippi, Missouri, Potomac, etc., represent a tremendous extent of potential fishing waters. However, it is the minor interior waters which actually account for the largest areas for potential fish production, particularly of game forms. When it is realized that small pond farms and reservoirs down to one half acre in area, as well as insignificant streams and brooks throughout the country, can be and are quite productive of some species of fish, it will be seen that a listing of the potential fish habitats is in reality a complete summary of the entire water resources of the United States. Pollution has, it is true, eliminated some of these resources from consideration as fish habitats; but on the other hand there are constantly being created new areas by impounding waters for hydroelectric development, irrigation, flood control, and other purposes.

While it is not possible to make even a valid guess as to the exact acreage or mileage of fishing waters in this country, some concrete examples may be cited merely as an indication of the magnitude of the problem. The United States Forest Service advises that in existing national forests there are listed 58,194 miles of streams and 159,742 acres of lakes which may be considered as potential fishing waters, whatever their value for this purpose at the present time. The State of New York has been foremost in the scientific evaluation of its water resources from a fisheries standpoint. Two watersheds alone in New York State, including a typical forested area within the Adirondacks, have an approximate area in lakes of 54,008 acres and an approximate stream mileage of 6,402 miles. Even in arid and semiarid sections as in the Southwest there are sufficient permanent water courses to justify an extensive demand for fish from Federal hatcheries, and the areas to be stocked are constantly increased by the impounding of water for the purposes specified above. It is merely necessary to view States like Maine and Minnesota to realize that a considerable proportion of the total area of these States is actually under water and that the area covered by the thousands of lakes must render its economic return largely as a recreational asset in which the production of fish either for food or sport is probably a major item. The absence of a Nation-wide summary of fishable waters should not cloud the self-evident fact that problems concerning this resource are of national scope and importance.

EXTENT AND VALUE OF ANGLING FOR RECREATION

As there is no evaluation of the actual potentialities of fish production in the interior United States, there is likewise no compilation of valid figures showing the extent and value of angling for recreation. It is possible to cite the value of commercial fisheries in strictly interior waters. Selecting only the commercial fisheries of the Mississippi River and tributaries in order to avoid the confusing factor of the maritime fisheries, it may be said that in 1930 these commercial fisheries had a production value of $4,385,000, with a yield in pounds of 108,171,000. It is indicated by the investigations of the Bureau of Fisheries in the Mississippi River for a number of years that changes taking place in the river, principally connected with erosion, are having a detrimental effect upon the fish production. The rôle of erosion in a forestry program is discussed elsewhere.

Probably the most complete data on the economic importance of angling are embodied in the Report of the Special Senate Committee on Conservation of Wild Life Resources, Report No. 1329, Seventy-first Congress, third session. This report cites license figures tending to show the public interest in fishing and hunting, and indicates that 13,000,000 people indulge in this sport. Due to the practice of a number of the States in covering hunting and fishing by a single combination license, it is impossible to ascertain the exact number of individuals who took out licenses for the specific purpose of fishing.

However, investigations by the Bureau of Fisheries show that for the period ending June 30, 1932, there were approximately 4,850,000 State licenses issued which carried the privilege of angling. These licenses paid in slightly under $8,000,000 during this period for the above privileges. Senate Report No. 1329 further states that the value of fishing tackle sold annually is estimated by a trade association as being $25,000,000.

Further light may be thrown by a citation of the expenditures involved in the maintenance of the supply of commercial and game fishes. There are in operation by the State and Federal Governments and private interests approximately 650 establishments devoted to the propagation of fish. The State and Federal hatcheries require the services of approximately 1,500 employees, and the combined expenditures of both agencies during 1932 were approximately $4,500,000. The investment of the Federal Government in its fish-hatchery system is approximately $3,500,000. There were distributed from the combined hatchery systems over 11,000,000,000 fish and eggs during 1932, of which approximately 1,000,000,000 comprised game species planted in interior waters and directly affected by the relationships of forests to waters. It should further be pointed out that there is an interchangeability between the game fishes and the so-called commercial varieties. With one or two exceptions, all of the so-called commercial varieties of the interior section are taken to some extent by the angler for recreation, and in many instances anadromous forms (fish which migrate from salt water to fresh water for spawning) are likewise sought by the angler.

IMPORTANCE OF MAINTAINING AREAS FOR PUBLIC FISHING

There is at the present time a tendency, possibly more emphatic in connection with game, but readily noticeable as regards fish, toward the exclusion of the public from the more desirable angling waters. Private ownership has not as yet taken an extensive hold in the exploitation of the commercial fisheries of the interior waters. As regards angling, however, private ownership now frequently yields to a favored few the privileges of angling which the country has been accustomed to view as a general public right. Landowners under trespassing laws may in many States prohibit access by the public to waters on their property.

Clubs are leasing extensively desirable stretches of water, which forces the casual fisherman of limited financial resources to travel farther and farther afield for catches which are becoming increasingly unsatisfactory. The importance of this condition in the more thickly populated sections is indicated by the action of the State of Connecticut in leasing private streams or leasing fishing rights for the public. The commendation which has followed this plan in Connecticut and the favor with which it is viewed elsewhere is an example of the lengths to which a commonwealth may have to go in order to insure the perpetuation of a right which was considered inalienable a few years ago. In the State of New Jersey, for example, it is apparent that the major part of public fishing is maintained solely by hatchery operations. In one sense, the purchase of a fishing license in that State is a transaction which has the element of sale of game fish produced by the funds derived from the license income. The hatcheries produce sufficient fish to provide the angler a reasonable chance for a reasonable catch, and the waters are, in a sense, administered by the State for the purpose of providing an expendable resource in the form of game fish. An essential feature of the successful working of this system is an adequate mileage of public waters accessible to everyone who has paid the license fee. Where there is a considerable proportion of the fishing waters restricted to private use the hatchery operations are futile and the whole program fails. Therefore, lands held in public ownership or control for forestry purposes are a double insurance against the ultimate disappearance of public fishing by virtue of the fact that they furnish the maximum natural provision for the survival of fish life and make this resource available to all. Waters leased exclusively for the provision of public fishing, as is the case in Connecticut, represent a charge against fisheries conservation funds. The retention of lands for public forestation or forest-management programs brings the above benefits without cost in addition to the primary purposes impelling the sequestration of such lands. The public funds derived directly from the angler are thereby available entirely for the purpose of improving angling.

The extensive withdrawal of private waters from public fishing and the growing popularity of angling has greatly increased the burden which must be borne by the waters held in public ownership. Consequently, it is imperative that a system of fishery management be developed which will yield the greatest possible return from the money and labor devoted to the improvement of angling conditions.

FISHERY MANAGEMENT

As a result of the continually increasing drain on the fish population many waters which only a few years ago were well stocked with fish are now seriously depleted. This is especially true in the national forests and parks where the great influx of campers has resulted in serious overfishing in the more accessible streams. Complaints that the fishing is becoming poorer each year are heard on every hand, and it is apparent that unless greater efforts are made to maintain the supply of game fish many of our waters will become so depleted as to furnish little sport for the angling fraternity. There can be no question that the stocking of streams and lakes with artificially reared fish has been of immense value in maintaining the supply of game fishes, but it is evident, in many cases, that this alone is not sufficient to enable us to reap the greatest benefit from our public waters. Since true conservation consists not in hoarding but in using wisely any policy of fishery management must have as its goal the greatest production of fish for the use of the public.

METHODS AVAILABLE FOR CONSERVATION AND UPBUILDING OF FISH SUPPLY

Four well known methods are available for the conservation and upbuilding of our supply of game and food fishes and should enter into any well organized system of fishery management in forest areas. These are: (1) introduction of fish into suitable waters in which they are not native, (2) artificial propagation and stocking, (3) protection from overfishing and (4) improvement of streams and lakes to provide more favorable conditions for fish.

(1) The first method—the introduction of fish into waters in which they did not previously occur—has been frequently utilized in the past, and it is in this field that fish culture has achieved some of its most notable triumphs. There are numerous instances where fish have been introduced into new waters with extraordinary success. The introduction of rainbow and brown trout in suitable waters in our Eastern States is a case in point. This has been followed by the equally successful introduction of the eastern brook trout in many streams in the West. Other game fish such as lake trout and bass have been successfully established in waters both east and west where they were not native.

Possibly some of the greatest achievements in this field have been the successful stocking of streams and lakes in which, due to the presence of impassable barriers, there were previously no fish whatever. Many of these waters now support a large fish population and furnish excellent sport to the angler. In the high mountains of our

Western States there are still many so-called barren lakes which are capable of supporting large numbers of fish if properly stocked. Of course, some of these lakes are for one reason or another not adapted to fish production but this can be readily ascertained by investigation.

(2) The value of artificial propagation in maintaining and increasing our supply of trout, bass, and other game fishes has been so conclusively demonstrated as to require no discussion at this time. There is still, however, much to be done in the development of better and more efficient methods of handling these fish in our hatcheries. There are even greater possibilities for improvement in the methods of disposing of the fish after they leave the hatchery. Undoubtedly in the past a large part of the benefits to be expected from the use of hatchery fish have been nullified by improper methods of stocking. Too often the fish have been planted in waters to which they were not adapted or under conditions where they would be overcrowded or unduly exposed to the attacks of their natural enemies. The proper utilization of artificially reared fish can only be accomplished through the development of a scientific stocking policy directed by experts in this field, which will take into consideration the species of fish best adapted to each individual stream or lake, the number of fish it can support, and the age at which they should be planted to produce best results. These and other factors must be fully evaluated before a definite policy is decided upon.

In most cases artificial stocking should be considered as supplementary to natural propagation and not as supplanting it. Some fish culturists have assumed that artificial propagation is so superior to the natural process that to all intents and purposes the latter may be disregarded. It is believed that this is an entirely mistaken attitude and that the proper function of artificial propagation is to remedy the deficiencies of the natural process.

In some waters it is no doubt true that for various reasons natural propagation is no longer to be considered an important factor and in such cases it is obvious that practically the entire burden must rest on artificial propagation. Fortunately, for the present at least, this is only true in a few localities near large centers of population where anglers are exceptionally numerous or in waters where conditions are no longer favorable for natural spawning. On the other hand, it is evident that in heavily fished waters even though conditions may be favorable for natural propagation the drain on the fish population is so great that natural spawning alone can no longer be depended upon to maintain it at its proper level. Consequently, this deficiency must be made up by the addition of artificially reared fish.

(3) Closely associated with the maintenance of natural propagation is the necessity for various forms of legal protection such as limitation of the daily catch, closure during the breeding season, the setting of size limits to enable the fish to reach sexual maturity and the closure of nursery streams. Unless this is done it is self-evident that in many instances there will be little opportunity for the fish to reproduce naturally. In some heavily fished waters it is becoming apparent that a further curtailment must be made in the bag limit and in the length of the open season if the fish are to continue to maintain themselves.

(4) In spite of these measures it is becoming more and more difficult to maintain a supply of catchable fish, and it is apparent that in order

to get the greatest possible benefit from the utilization of our waters we must have recourse to the principle of stream improvement or control. Although it is evident that the idea of environmental control is sound in theory, there has been very little practical application of the principle in this country. In Great Britain the importance of stream conditioning has long been recognized and notable success has attended its practical application to trout streams.

The purpose of stream improvement is to make the stream a better place for fish to live. Less attention has been paid to lakes, but it is evident that the principle is also applicable to them although its practical application will be more difficult. The basic idea of stream improvement is to ascertain what factors are limiting the abundance of catchable fish and then proceed to overcome or remedy the natural deficiencies. There are probably very few lakes or streams which cannot be improved to some extent, and in many instances it is possible materially to increase the production of fish at comparatively small cost.

While different species of fish frequently differ widely in their requirements in respect to certain features of their environment, there are other fundamental requirements in which most species are in essential agreement. These factors are a stable environment, pure water, adequate shelter for young and old, sufficient food for fish of all ages, and adequate spawning areas. A deficiency in any one of these requirements may result in its becoming a limiting factor even though in all other respects the stream or lake may be able to support a much larger population. If we regard a body of water as a complex biological unit, it is apparent that the correct balancing of conditions is of the greatest importance. The overdevelopment as well as the underdevelopment of any one factor should be avoided if we wish to obtain maximum production. For instance an unlimited increase in spawning facilities or in stocking would throw the fish population out of balance in relation to the food supply. The greatest annual production will be obtained when there are just enough and not too many individuals in relation to the food.

The importance of a stable environment can scarcely be overemphasized. As previously pointed out, streams or lakes with great fluctuations in the water level are much less productive than those in which the level is fairly constant. Anything which will tend to check rapid fluctuations such as the construction of dams or other obstructions which will impound the water or impede its flow will obviously be beneficial to the fish. The importance of beaver dams, for instance, in improving conditions for trout has frequently been emphasized. Obviously this phase of stream improvement is closely linked with the problem of flood control since, in general, any measures which will tend to impede the run-off will be of direct benefit to the fish. Measures which will reduce the volume of flow will also tend to reduce erosion and the deposition of large quantities of sediment, the evil effects of which have already been referred to. The beneficial effects of reforestation in this connection can scarcely be overestimated. Any cover which will reduce the run-off and erosion cannot fail to have a beneficial effect on the streams and increase their capacity for carrying fish.

Needless to say, one of the prime requirements for the production of fish is an adequate food supply, and it is probably true that in the last analysis this is the most important factor in determining the number of fish which a body of water will support. It is also true that in many streams it is a comparatively simple matter to increase the amount of available food. Logs, boulders, and gravel greatly increase the hard stratum over which insects may crawl and also serve as a support for an abundant growth of algae on which they feed. Weed beds, especially of the submerged type, provide very favorable conditions for the growth of food organisms. Comparatively little is known, however, of the conditions which will promote the growth of many plants and animals utilized as food and much remains to be done before we will be in position fully to utilize the food-producing capacity of natural waters.

Shelter and food should be considered in relation to one another since most shelter devices tend to increase the supply of food. The functions of shelter are primarily for protection, but in fast-flowing streams such devices may slacken the current so that the fish may rest. It also appears that sections of streams or lakes where adequate shelter is present are more attractive to fish. Conversely many sections of streams or lake margins are practically free of fish owing to the absence of shelter. It has been shown recently in the case of Michigan trout streams that long stretches of heretofore troutless waters can be made to yield good catches of adult fish by the installation of proper shelter devices.

Shelter may be provided in many forms and degrees. Almost any obstruction in the water gives some shelter and a few twigs or pebbles may suffice for small fish. In streams shelter can best be provided in connection with pools. Logs and boulders are soon undermined by the combined action of fish and current and furnish excellent places for the fish to hide. Weed beds also provide excellent shelter, especially for young fish. Deflectors or dams so constructed as to cause the stream to undercut its banks are very effective.

A prime requisite for a permanent fish population is the provision of adequate spawning facilities. These, of course, will take different forms according to the species of fish concerned. In the case of trout, gravel beds in spring-fed streams are required, and the lack of such beds is not infrequently a limiting factor. In some instances such beds can be provided by the installation of deflectors which will cause the current to sweep away silt or sand covering old gravel deposits. In other cases it may be necessary to haul gravel for this purpose. Small-mouth bass also require gravel beds near the lake shore or in the bed of streams while large-mouth bass spawn on mud bottoms where the roots of plants can be easily exposed by the fanning action of the fins.

Pollution is usually not an important factor in forested areas, but in some cases sawdust or refuse from mining operations may cause considerable damage. Their effect is much the same as that of silt, being especially destructive to the eggs of fish and to their food.

MEANS OF CARRYING INTO EFFECT A PROGRAM OF FISHERY MANAGEMENT IN THE FOREST AREAS

AGENCIES CONCERNED

There are many agencies concerned with the propagation, distribution, stocking, utilization, and management of the fishery resources of the United States. These include various branches of the

Federal, State, and local governments, but the complete coordination of activities of these agencies in a general program of fishery management is yet to be attained. That Congress is aware of the necessity for unified action in the interest of wild-life conservation from a national point of view is evident from numerous reports upon the subject and from certain pending legislation.

Functions of the various national agencies and their responsibility in the whole field of wild-life conservation have already been discussed in Senate Report No. 1329 mentioned elsewhere. In this report the Senate Committee on Conservation of Wild-Life Resources expresses the conviction that the major part of a successful conservation program in the preservation and replacement of wild life belongs to the various States, but that without active participation and the leadership of the Federal Government the work will fail. The Committee also expresses the view that the Park Service and the Forest Service are the two major Federal Bureaus principally responsible for the preservation and replacement of wild life by reason of the control which they exercise over great areas of the publicly owned land. These two organizations, however, and especially the latter, are concerned with major problems in their own fields frequently of great technical complexity, and they must of necessity depend upon the expert advice and assistance of two other Federal bureaus: for the development of a program of game management, Bureau of Biological Survey; and for fishery management, the Bureau of Fisheries. In an effort more clearly to define and coordinate the functions of these Bureaus, the bill entitled "An act to promote the conservation of wild life, fish and game, and other purposes" (S. 263, 72d Cong.), passed by the Senate December 17, 1931, and now pending before the House of Representatives, provides that the Secretary of Agriculture and the Secretary of Commerce be authorized to provide expert assistance to Federal, State, and other agencies in rearing, stocking, and increasing the supply of game and fur-bearing animals and fish; in combating disease and in developing a Nation-wide program of wild-life conservation and rehabilitation, and to cooperate with such agencies to that end.

Another bill entitled "An act to provide consideration of wild-life conservation in the construction of public works or improvement of projects" (S. 5813, 71st Cong.), passed by the Senate January 26, 1931, requires consideration of the effect of the construction of any public works or improvements upon the replacement and conservation of wild life and requires the Bureau of Fisheries or any other agencies of the Government, whose activities are concerned with conservation, to advise and confer with the construction agency with a view to determining the most appropriate methods for carrying out such construction with the least injury to wild life.

In discussing the functions of the various Government agencies, the Senate Wild Life Committee in Report No. 1329 summarizes the work of the Bureau of Fisheries in connection with the conservation of fishery resources in the following words:

> This is the predominating agency for the collection and dissemination of scientific and practical information concerning this resource. The cooperation of other Federal agencies whose projects or operations are such as to affect fish life or to require administration of it by the agencies concerned should be obligatory. Federal agencies in charge of drainage projects or other projects influencing water levels, erosion, or water pollution, should be required to advise

and consult with the Bureau of Fisheries to prevent unnecessary damage to fish life and to emphasize such beneficial results as may occur under proper management from such operations.

The Bureau of Fisheries maintains experimental stations and hatcheries. In cooperation with other Government, State, and local agencies, the Bureau assists in the distribution of fish, the control of inimical or undesirable forms, in research work and educational activities. This Bureau has responsibility toward the maintenance of valuable fish life in waters in the public domain and should be enabled to assign biologists and skilled fish culturists to the national-forest areas to conduct and supervise stream and lake surveys and develop a rational policy, in cooperation with States, of stocking such waters, to give instruction to rangers and others having the direct responsibility of planting fish and in general to further the execution of an orderly national program of replacement.

To further cooperation on fishery management in forest areas a series of conferences between the Forest Service and the Bureau of Fisheries culminated during the past year in a general agreement regarding the responsibilities of the two Bureaus. It was agreed that the Bureau of Fisheries recognize its responsibility in stocking waters in the public domain with food and game fishes, particularly in the national forests and parks. As a part of this responsibility it was recognized that scientific surveys of forest waters are necessary as a basis for drafting a rational program of fish planting. The Bureau of Fisheries accepts responsibility for the production of food and game fishes by artificial propagation through the feeding stage up to the time of delivery of the fish for distribution. At this point the Forest and Park Services receive and distribute the fish produced by the Bureau of Fisheries for planting in natural waters in accordance with their predetermined plan of stocking. In this way it is believed that maximum efficiency in stocking public waters will be attained, for the Forest and Park Services are best prepared to secure and coordinate cooperation in planting operations by individuals and sportsmen's organizations.

It is understood that the various States should at this time be responsible for the enactment and enforcement of laws relating to the taking of fish and the screening of irrigation ditches; moreover, they should cooperate in the artificial propagation of fish where existing Federal services are inadequate, but should not undertake the planting of fish in the public domain except in accordance with the Bureau's stocking policy and with its permission.

To carry out this plan the Bureau proposes the organization of a fishery survey in each of the six national-forest areas of western United States under the direction of a resident biologist in each area, who shall conduct and supervise stream and lake surveys in waters of the public domain and shall develop therefrom a rational policy of stocking such waters with fish. In addition to the research units, skilled fish culturists are to be detailed to each forest region to assist in determining the needs for and organization of rearing and holding ponds, to assist in the planting and distribution of fish from hatcheries, and to give instructions to rangers or others charged with the responsibility for the planting of fish.

It is obviously impossible to complete the survey work under such a program in the 167 national forests and parks in the continental United States in less than 5 years with even an adequate personnel, and under the present circumstances with reduced appropriations the program will be materially delayed. Nevertheless, a start has been made, and biologists of the Bureau have made surveys during the past 2 years in national park and forest areas in regions nos. 1 and 4, including Montana, Wyoming, and Utah, and in region 5 in California. In view of the importance of maintaining fish life, especially in heavily fished areas adjacent to popular routes of travel, the work should be continued as rapidly as possible.

Fish-hatchery equipment is being extended in these areas. The Bureau maintains two hatcheries expressly for the purpose of stocking national parks and a third in Mount Rainier National Park is nearing completion. A district supervisor of fish culture has been appointed with headquarters at Salt Lake City, Utah, to coordinate all activities in the intermountain region, embracing the greater number of national parks and forests.

In the course of the past year efforts were initiated to attain closer contact with the Bureau of Reclamation, Department of the Interior, since the activities of that agency in constructing irrigation projects, particularly in the Northwest, have a strong bearing on the welfare of important fisheries. In most cases these fisheries may be preserved or subjected to a minimum damage by giving attention to the installation of adequate fish ladders in the dams or by the proper screening of diversion canals for irrigation. The main thought for consideration in connection with both State and Federal agencies working in allied fields is to assure that the various projects shall be actually carried on by the agency best qualified to effectively accomplish the object sought, at the lowest practicable cost.

In view of the fact that Federal agencies assume responsibility for maintaining stocks of fish in waters of the national forests and parks, little need be said with regard to functions of State governments in this connection except as concerns fishery legislation. Federal influence on fishery legislation by States is indirect but generally effective inasmuch as recommendations when offered to the States are unbiased by local interests and are based upon authoritative information. Moreover, the Bureau is authorized to discontinue fish cultural or planting operations in any State if regulations are inadequate or enforced insufficiently to protect the supply of fish in the lakes and streams. The Federal Government directly aids the States in the enforcement of laws prohibiting the sale or interestate shipment of black bass through the recent enactment of a Federal black bass law, and an enforcement officer with several deputies in various sections of the country have been appointed.

It would appear desirable, however, for the agencies responsible for the full utilization of forest areas to have more direct control of the utilization of fish in addition to the mere responsibility of producing and planting the supply. Such control is feasible in closely controlled areas such as the national forests and indeed is an essential feature of effective fishery management as mentioned above. It is not proposed in this connection to abrogate State rights by an extension of Federal authority, but regulative power, such as is exercised in the national parks, might well be extended to the national forests, especially those to be acquired in the future whereby the responsible agency might provide additional protection for threatened supplies of fish in particular waters by still further restricting bag limits, size limits, or closed seasons or areas provided by State laws. The entire question of legal restrictions upon fishing in forest areas and its relation to the development of a program of fishery management is of utmost importance, but it is believed that no detailed plans in addition to those mentioned above can be made until basic information derived from the surveys now under way by the Bureau is available.

Close cooperation between the Federal Bureau of Fisheries and the State fish and game commissions has been maintained for many years, extending even to pooling of fish cultural resources, exchanging eggs and fry, loaning technical personnel, and distributing and planting fish. A statement of further details along this line appears unnecessary, but the Bureau feels that sentiment in practically all the States is such that when occasion arises cooperative relations of mutual benefit may develop.

The attitude of the large sportsmen's organizations, individual sportsmen, and commercial fishing interests leaves no room for the conclusion that there is an excess distribution of hatchery fish or a surplus of facilities for their production. In view of this situation the operation of both Federal and State hatcheries within any given area cannot fairly be considered a duplication of effort, since too frequently their combined output is not adequate to meet the purpose for which intended, namely, the maintenance of an abundant stock of food and game fishes. In the practical execution of these enterprises cooperative programs may be developed which will insure more effective work by the agencies concerned and prevent overlapping or duplication of effort in some particular area without affecting the essential truth that a vast field is not being thoroughly and adequately covered. This cooperation is largely in the nature of technical management and more effective routine administration. During the past year the Bureau maintained effective and mutually beneficial affiliations with some 22 States. In the majority of cases the States were the principal beneficiaries, which is in line with the original concept of the Bureau's activities to aid and promote Satte conservation work.

RESEARCH REQUIRED

From the foregoing sections it should be apparent that there are so many technical problems involved in establishing a comprehensive program of fishery management in forest areas, concerning which there is disagreement and controversy or lacking information, that scientific research is essential to the fullest utilization of the natural resources of these areas. The first requirements of a research program therefore include the physical assessment of the forest areas themselves from the point of view of water resources on the one hand, the fish populations present in the various districts, and the demands made upon these natural supplies by the fishermen.

For the purpose of fishery management much more information is required regarding the physical features of the individual forest areas than is available from topographic maps provided by the Geological Survey or the Forest Service. In addition to the actual location of streams and lakes and their dimensions, the fishery officers must have information regarding the flow of streams and their seasonal fluctuations, the character of the stream bed, the extent of riffles and pools, the physiography of the watershed, and the chemical composition and thermal relations of the water. All of these factors influence more or less directly the biota, both land and aquatic, of the forest water areas.

In addition to these physical features, the fishery officers should have a reasonably complete understanding of the biological conditions in the area subject to management, especially the fauna and flora of the waters themselves. This applies especially to a quantitative as well as a qualitative assessment of the organisms present in the water and available from adjacent land areas, which are suitable as food for fishes.

A further requirement is an assessment of the existing fish populations. The different types of ecological associations among the various species of fish are reasonably well known, and their relation as competitors or predators of the more valuable game fishes in most cases is well established; but the numerical relation of the components of the fish fauna, insofar as they can be readily determined, is of prime importance to the fishery administrator, for the aim of fishery management is to produce from a given area the maximum number of food fishes of the most desirable or useful individual sizes. To assemble this information it is necessary for the fishery biologist to personally survey the waters of each forest area, making detailed observations to determine existing conditions. Such stream and lake surveys are now under way in forest and park areas in the intermountain region by the Bureau of Fisheries as mentioned above.

While conducting these stream surveys, however, it is necessary for the biologist to consider an additional factor, namely, the demands upon the supply by the existing or potential fishery. At present facilities for determining the drain upon the supply are very inadequate. In national parks the number of tourists visiting the areas in the year can be accurately determined. Park officers and forest rangers can also maintain a general check upon the number of fishermen in any given watershed. There seems at present to be no practical method, however, of determining the annual take of fish of any species in the public domain. A completed program of fisheries management should include the furnishing of such figures not only to determine the need for additional production but to provide a more accurate check upon the success of methods devised and applied to increase the yields.

In addition to conducting extensive physical and biological surveys of streams and lakes in forest areas as a foundation for a rational stocking policy in these waters, more intensive studies of the ecological requirements of the fish to be planted are required. These may be called experimental studies in field ecology, for they contemplate the establishment of areas such as individual stream systems or smaller lakes in which controlled experiments may be conducted bearing upon the various factors of production. In such experimental waters means of augmenting the food supply and the value of various food components may be studied. The effect of competing species upon each other may also be determined, proper levels of stocking intensity can be determined, the migratory and breeding habits of the various species can be investigated, and the general effects of each particular system of management can be assessed.

Closely associated with experiments in field ecology are laboratory studies for the purpose of improving hatchery technique. Studies in this field conducted by the Bureau of Fisheries during the past several years have been successful in improving feeding rations in hatcheries and in combating disease. Notable progress has been made also in demonstrating the effectiveness of using improved strains of breeding stock to increase productiveness and the rate of growth, and to heighten resistance to disease. Improved methods of prophylaxis and treatment of diseases occurring in hatcheries have also been devised. Much remains, however, to be done in these directions, and especially must the principles devised in existing experimental stations be adapted and applied to the particular conditions that obtain in national forest areas of the West. The resident biologist in the forest areas therefore must take active part in these experimental studies, both in the field and laboratory, as well as in the stream survey programs, in order to make proper use of the survey data in the management of the fish supplies. In view of the vast areas to be covered and the diversity of technical problems requiring attention, it should be obvious that no single biologist is capable of carrying on effectively all phases of the work simultaneously, but that sufficient technical personnel should be provided to make division of the work possible, thus assuring the acquisition of the most essential information at the earliest moment.

Obviously many years will elapse before an area so great as that covered by the national parks and forests of the United States is brought under such a system of fishery management as is outlined in the foregoing pages. The program, it is believed, is practical and workable, however, for regardless of the extent of personnel or funds available any progress made in the program of investigation, propagation, stocking, or improvement will have immediate value. Even the information obtained from an area covered by a single season's operations will provide a far sounder basis for fish stocking in that area than exists at present, and within a few years time, with adequate working support, a sufficient area will be brought under scientific control to vastly augment the supply of food and game fishes and to assure the perpetuation of this resource.

FOREST RANGES

By W. R. Chapline, Chief, Division of Range Research, and R. S. Campbell, Associate Forest Ecologist, Southwestern Forest and Range Experiment Station[1]

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FORAGE—AN IMPORTANT FOREST LAND RESOURCE

The forage produced by herbaceous and shrubby plants under the trees and in openings in the forest is one of the major resources of forest lands. The proper utilization of the forage resource by domestic livestock and game animals is therefore of primary importance in multiple-use management which seeks to obtain the maximum contribution to the national welfare, by a proper correlation of all the products, uses, and services of forest lands. The forage cover of forest lands plays an important role in the production of the Nation's domestic meat and wool supply and furnishes a livelihood to the stockmen whose herds or flocks graze it. It also supports a large and valuable wild-life resource and produces numerous miscellaneous by-products.

The use of the forage resource of forest lands primarily by domestic livestock, but to an important extent in some localities by game animals, vitally affects the management of such lands in several ways: (1) It is a source of direct current financial return; (2) it affects the reproduction of the timber crop; (3) it has a direct bearing on the value of the forest land for watershed protection, and (4) it has a direct influence on fire protection.

The forest land grazing problem logically divides into three important phases: The western-range phase, that which predominates in the South, and the pasture type in the farm woodlands. In the West the problem centers around the utilization of large areas principally of public land by many private owners of ranch property and livestock. In the South it largely concerns the use of extensive private forest areas often not owned by the stockman yet of decided value to the rural population. In the farming regions of the Central States, and in parts of the New England, Middle Atlantic, and Lake States, it involves small woodland areas on farms into which the farmer turns his livestock. Thus the forest-range problem is one of broad social economy and land utilization. It affects directly or indirectly the permanent prosperity, development, and welfare of a considerable part of the Nation. The forest and forage conditions, as well as the character of use under each of the three major forest-grazing situations, are so distinct that each is considered separately.

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[1] Acknowledgment is due George Stewart, Hugh O. Cassidy, and Gordon D. Merrick for cooperation in the assembling of data for this section.

WESTERN FOREST RANGES

EXTENT AND IMPORTANCE

The extensive forest ranges of the West, largely occupying the mountain areas, furnish a considerable percentage of the summer feed for the beef cattle, sheep, and range horses of the Rocky Mountain and Pacific Coast States. This region coincides with the three western forest regions of "Forest Land the Basic Resource" section of this report. It is composed of those States entirely west of the 100th meridian, and South Dakota. The region as a whole contains more than 214 million acres of land classed as forest, of which it is estimated that nearly 144 million acreas are grazed. (Table 1.)[2] These forest ranges include the relatively small parts usable for grazing of the dense forests such as the spruce-fir of mountain areas, the Douglas fir and redwood forests of the Pacific Coast, the lodgepole pine of the Rocky Mountains and Cascades, and the chaparral of California. They include the more open forest areas such as the ponderosa pine type, found from the Canadian to the Mexican borders and from the Great Plains to the Cascades and Sierra Nevada; and the woodland areas usually forming the lower fringe of the forest. Included also are the aspen forests largely in the Rocky Mountain States and the large areas of usable brush lands which are potential forests. In addition to these forest areas is a large acreage of open grassland and usable brush land so intermixed with the forest ranges that their utilization is an intergral part of the whole.

TABLE 1.—*Estimated areas of commercial and noncommercial forest lands grazed by livestock in the United States, by regions and classes of ownership*

COMMERCIAL AREAS

[Thousand acres]

Region	Total	Federally owned or managed					State	County and municipal	Private		
		Total	National forests	Indian reservations	Public domain	Other			Total	Farm woodland	Industrial
New England	3, 150	3	3	------	------	------	------	------	3, 147	3, 147	------
Middle Atlantic	3, 655	100	100	------	------	------	------	------	3, 555	3, 555	------
Lake	10, 852	15	------	------	15	------	------	------	10, 837	10, 837	------
Central	23, 635	500	500	------	------	------	23	------	23, 112	18, 560	4, 552
South	126, 870	2, 489	2, 433	56	------	------	258	------	124, 123	19, 530	104, 593
Pacific coast	36, 411	18, 901	15, 450	2, 622	432	397	550	75	16, 885	4, 167	12, 718
North Rocky Mountain	18, 330	13, 627	12, 643	464	520	------	374	------	4, 329	2, 378	1, 951
South Rocky Mountain	23, 359	18, 937	14, 940	1, 817	2, 180	------	361	------	4, 061	28	4, 033
Total	246, 262	54, 572	46, 069	4, 959	3, 147	397	1, 566	75	190, 049	62, 202	127, 847
Eastern regions (except South)	41, 292	618	603	------	15	------	23	------	40, 651	36, 099	4, 552
Western regions	78, 100	51, 465	43, 033	4, 903	3, 132	397	1, 285	75	25, 275	6, 573	18, 702

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[2] In this table, using as a basis the total commercial and noncommercial forest areas shown in "Forest Land the Basic Resource" section of this report, the estimated areas of forest land grazed by domestic livestock were calculated from Forest Service records and observations, the 1930 census, and "An economic survey of the range resources and grazing activities on Indian reservations", by Lee Muck, P. E. Melis, and G. M. Nyce, in hearings before a subcommittee of the Committee on Indian Affairs, U.S. Senate, 71st Cong., 2d sess. S.Res. 79, 308 (70th Cong.), and S.Res. 263 and 416 (71st Cong.), 1932.

TABLE 1.—*Estimated areas of commercial and noncommercial forest lands grazed by livestock in the United States, by regions and classes of ownership*—Contd.

NONCOMMERCIAL AREAS

[Thousand acres]

Region	Total	Federally owned or managed					State	County and municipal	Private		
		Total	National forests	Indian reservations	Public domain	Other			Total	Farm woodland	Industrial
New England	1	1	1								
Middle Atlantic											
Lake	94	25			25				69	69	
Central	315	84	84				22		209		209
South	22, 138	296	296				165		21, 677	14, 337	7, 340
Pacific coast	8, 959	4, 574	3, 110	193	1, 271		22		4, 363	3, 886	477
North Rocky Mountain	4, 585	3, 631	2, 637	456	538		59		895		895
South Rocky Mountain	52, 006	38, 283	14, 974	6, 520	16, 689	100	2, 644		11, 079	4, 827	6, 252
Total	88, 098	46, 894	21, 102	7, 169	18, 523	100	2, 912		38, 292	23, 119	15, 173
Eastern regions (except South)	410	110	85		25		22		278	69	209
Western regions	65, 550	46, 488	20, 721	7, 169	18, 498	100	2, 725		16, 337	8, 713	7, 624

ALL AREAS

Region	Total	Federally owned or managed					State	County and municipal	Private		
		Total	National forests	Indian reservations	Public domain	Other			Total	Farm woodland	Industrial
New England	3, 151	4	4						3, 147	3, 147	
Middle Atlantic	3, 655	100	100						3, 555	3, 555	
Lake	10, 946	40			40				10, 906	10, 906	
Central	23, 950	584	584				45		23, 321	18, 560	4, 761
South	149, 008	2, 785	2, 729	56			423		145, 800	33, 867	111, 933
Pacific coast	45, 370	23, 475	18, 560	2, 815	1, 703	397	572	75	21, 248	8, 053	13, 195
North Rocky Mountain	22, 915	17, 258	15, 280	920	1, 058		433		5, 224	2, 378	2, 846
South Rocky Mountain	75, 365	57, 220	29, 914	8, 337	18, 869	100	3, 005		15, 140	4, 855	10, 285
Total	334, 360	101, 466	67, 171	12, 128	21, 670	497	4, 478	75	228, 341	85, 321	143, 020
Eastern regions (except South)	41, 702	728	688		40		45		40, 929	36, 168	4, 761
Western regions	143, 650	97, 953	63, 754	12, 072	21, 630	497	4, 010	75	41, 612	15, 286	26, 326

These forest ranges have represented on them nearly every character of ownership prevailing in the West—Federally owned and managed, State, and private. There are large Federal holdings. Of the 88 million acres of usable range lands within the national forests almost 64 million acres are classed as forest. More than 21.5 million acres of the unreserved public domain are forest ranges. The Federally managed Indian reservations contain some 12 million acres of forest land usable for grazing. The forest lands usable for grazing in other Federal reservations and withdrawals amount to about half a million acres. It is estimated that about 4 million acres of forest land in State ownership is grazed. Forest ranges under other public ownership or management are small and probably have little influence on the forest-range problem of the West. It is estimated that almost 42 million acres of privately owned forest land are grazed, including 15 million acres of farm woodland (1930 census). The increase in tax-delinquent land to the public may materially enlarge the forest-range area in certain classes of public ownership and make it important locally.

Among the larger private holdings are the areas still held by corporations from the grants made as subsidies for construction of railroads and wagon roads and otherwise to encourage colonization and development. Many of these consist of alternate sections over extensive areas. The existence of land holdings in this form in a region where 640 acres is far from adequate as a range unit has complicated their management. Spanish and Mexican grants in the Southwest and California were usually made as solid bodies of land which, because of their relatively large size and continuity, are susceptible of management. Most of the large timber holdings are in the better commercial forest areas where forest growth is dense and grazing is a minor use. There are, however, in addition to these holdings a large number of small privately owned forest areas, most of which are grazed. In those areas where timber or woodland values are meager, many properties are held by their owners for the grazing value alone. Others serve as a base of operations for use of larger areas of adjacent public land.

Within or adjacent to almost every western forest range area are agricultural communities where prosperity is dependent upon the production of livestock. Many of the farms within these communities are small, far from markets and principally capable of producing hay or other feed crops. Without the aid of complementary forage furnished on the forest areas, a large proportion of these associated farm lands and the accompanying community life would never have reached the present stage of development. More than 4½ million acres of improved farm land and 22 million acres of private or leased grazing land, for example, are used in connection with the 83 million acres of national-forest land now grazed by domestic livestock.

The great bulk of the feed on the forest ranges is used by and the principal financial return comes from the cattle and sheep, although it also supports large numbers of horses and burros, mostly wild, some goats and hogs, and a few mules, to say nothing of game animals. It is estimated that during 5 to 8 months of the spring, summer, and fall these Western forest lands furnish feed for over 2½ million mature cattle, having a value in 1931 when prices were low of about $85,000,000, and also nearly a million calves. Most of the cattle are of beef breeds; in only a few localities are dairy cattle run on forest ranges. It is estimated from the 1930 census that they represent nearly 40 percent of all the mature range cattle in the Western States. Some go direct to market as killers, but a large part of them go into feed lots for finishing.

Nearly 12 million grown sheep, largely ewes, which had in 1931 a value of about $60,000,000, are estimated as grazing on forest ranges. The grazing period is from 3 to 5 months, chiefly in the summer, although in some places, grazing prevails in the spring, fall, or even winter. It is from these mountain-range areas that most of the lambs sold in the fall come. Since the average lamb crop is probably 70 percent, and these lambs graze in addition to the ewes, the large number of sheep grazed during a part of the year on forest ranges can be appreciated. Where the feed is abundant and succulent, many of the lambs go direct to market as killers. From the drier ranges, and especially those heavily used, most of the lambs are sold as feeders.

FORAGE PRODUCED

The ponderosa pine is the most extensive western forest type, reaching into nearly every State west of the one hundred and third meridian, largely on mountainous slopes and plateaus at relatively low elevations in the northern part of its range and up to 8,000 feet or more in places in the southern part. The type furnishes good feed practically wherever it occurs. Ponderosa pine and its associated tree species usually grow in stands sufficiently open to allow the development of a great variety of herbs and shrubs. Over most of the type the feed produced is mainly bunch grasses. Grama grass—an excellent forage species, is abundant on the eastern slopes of the Rocky Mountains and in the Southwest. Many range weeds and shrubs add variety to the feed.

The sugar pine—ponderosa pine forests, which are principally in California, are more dense than the typical ponderosa pine areas, and therefore less feed occurs on the forest floor. The understory vegetation is mainly of browse, a large part of which is composed of such palatable species as bluebrush, birchleaf mountain-mahogany, and bitterbrush. Many of the other brush species are of low grazing value. Grasses and range weeds are important in places, but on forest slopes tend to dry up by midsummer.

Another forest type which furnishes considerable forage in the West is the aspen type. It occurs at medium to high elevations, usually on deep, rich soils which it helps to build up. It is of importance in Utah, Colorado, Wyoming, Montana, parts of Idaho, and northern New Mexico and Arizona. Beneath the aspen, which ordinarily grows in rather open stands, is usually a luxuriant understory of palatable grasses, weeds, and browse that is grazed with relish by all kinds of livestock. The aspen itself is prolific in producing sprouts that are rather palatable to livestock but that can be seriously damaged by too great foliage and twig removal through browsing.

The lodgepole pine forest, which covers large areas in the central and northern Rocky Mountains and on the east side of the Cascades, usually occurs in stands too dense to allow satisfactory grazing, especially since most of the herbaceous and shrubby species present are of low feed value. However, in the more accessible open stands, some use is made of the forage produced. In the western larch-western white pine forests of northwestern Montana, northern Idaho, and northeastern Washington, the stand is so dense that there is even less grazing than in the lodgepole pine.

The spruce-fir forest, which occurs at higher elevations in the mountains of the West, produces little forage in the more dense stands. However, in the subalpine phase of the type, where the stands are more open and patchy, good feed is produced in the openings sufficient in quantity to furnish some of the best summer range in the West.

In the Douglas fir and redwood forests of the west coast, a heavy undergrowth, chiefly of ferns and of salal and other brush species, occurs in spite of the dense stand of timber, and because of its low forage value renders these areas practically worthless for grazing. After destructive fires a luxuriant growth of moderately palatable herbaceous and browse plants ordinarily prevails for some years until forest reproduction shades it out. Good feed is also produced for a number of years on cut-over areas of these forest types that have been reseeded to forage plants.

The woodland type, consisting mainly of juniper in the North, of piñon-juniper in the central and southern Rocky Mountain States, and of digger pine and juniper in California, occurs at lower elevations than the commercial timber types. On the plateaus and rolling lands of the central and southern Rockies there is usually a fair ground cover of grass, often grama, beneath the open stand of trees. In spite of the naturally sparse forage cover, which in many instances has been seriously depleted by overgrazing, the woodland type is an important part of the western forage resource. In the California woodlands bitterbrush, bluebrush, and birchleaf mountain mahogany are often important. Repeated burns in this type of extreme fire hazard tend to replace the palatable browse plants with worthless brush and inferior annual grasses and weeds.

The mountain brushlands, at the lower elevations of the central Rockies and in the Southwest, consist principally of low-value oak brush. At the higher elevations of the Rockies cherry, plum, and willows are important. It appears that the oak brush areas were once good range lands with moderately palatable grasses occupying a large proportion of the vegetative stand, but the grass has been so depleted by overgrazing and the low-value brush species have spread to such an extent that at present it furnishes satisfactory forage only on a relatively small part of the type. In California and Oregon there are thousands of acres of mountain brushlands which have practically no grazing value because of the dense stands of snowbrush and manzanita which have largely become established following fires.

FOREST RANGE CONDITIONS

Few areas of forest range are still in a virgin condition. The fact that most commercial and many of the noncommercial forest areas were fairly well watered and had a cool climate, together with the good feed that was present, gradually attracted livestock owners to the forest lands. As a result of the keen competition for open range at the lower elevations, settlers in increasing numbers either located openings in the forest or pushed their flocks back into the extensive forest areas. With free range, an apparent abundance of feed, and a prospect for quick profits, money poured into the western livestock business in the eighties and excessive overstocking became general followed by depletion of forage. Accentuated by periodic droughts, the destruction of the forage plants, especially in the openings, almost reached denudation on many areas. Fertile top soils were washed away, slopes and valleys were cut by gullies, and farm lands, irrigation works, and other improvements suffered excessive damage from floods and erosion debris. Timber reproduction was devoured by the hungry animals. Fires set in an effort to open up brush areas, or with the belief they would improve range conditions, not only in many cases seriously injured soil and range values but destroyed valuable timber as well and made its reestablishment more difficult.

Creation of national forests, their protection from fire, and the regulation of grazing on them tended to stop deterioration and restore to some extent the forage on that part of the western forest ranges. For example, the high mountain forest ranges of Utah, according to stockmen, were practically dust beds in the late nineties. Study by the Intermountain Forest and Range Experiment Station on one area in central Utah, after establishment of the national forest, showed that in a period of 15 years, the forage cover was, through careful management, restored sufficiently on the better soil areas to produce a grazing capacity four times greater in 1927 than in 1912. Similar improvement is recorded on many national forest areas in the West.

Some private owners, recognizing the folly of excessive use of their lands, have modified their grazing practices; but this has been almost impossible to accomplish where private holdings are so intermingled with public domain lands as to make complete use of the forage necessary to discourage intrusion of other livestock owners. Losses resulting from starvation in drought periods and forced shipments as a result of uneconomic conditions have relieved the public domain and most of the private lands for brief periods, but deterioration has continued on large areas of private and uncontrolled public forest lands, usually as a result of overstocking during periods with favorable markets, and as a result of recurrent drought.

Numerous examples might be cited of unsatisfactory range conditions still present on private and uncontrolled public forest lands and of their deleterious effects on the social, economic, and other conditions in the West. For example, on a private range in the ponderosa pine type of eastern Oregon the forage cover had been so closely grazed in 1920 that the area was practically a dust bed. Needles on the branches of timber reproduction within 3 feet of the ground had been eaten so completely that the branches were killed. Reproduction under 2 or 3 feet high was so closely grazed that it was making practically no growth, and the soil was so trampled that seedlings did not readily become established.

In Montana there is a large acreage of former grassland, occurring as scattered openings in the forest, on which the cover has been converted by overgrazing to low-value plants such as rabbit brush, yellow brush, and various weeds. W. G. McGinnies has found that this transition has reduced the grazing capacity of these areas from about 2 acres to about 11 acres per cow per month.

Studies by the Intermountain Forest and Range Experiment Station of spring-fall ranges in the foothills of Utah near the lower edge of the noncommercial forest type show losses of 40 to 90 percent in range values during the 50 to 60 years that they have been grazed. On areas protected from fire and grazing for a number of years, Pickford[3] found that the valuable native wheat grasses and bluegrasses constitute 68 percent and the practically worthless sagebrush only 11 percent of the vegetative cover. Tracts which have been overgrazed furnish only three fifths as great a grazing capacity as the protected areas, and they have much less perennial grass, more than twice as much sagebrush, and a materially larger stand of low-value annual grasses than the protected areas.

A striking constrast, showing the value of good range management and maintained forage and livestock production, is afforded by the Santa Rita Experimental Range in Arizona and the depleted adjacent public domain. Although these ranges are mainly untimbered, the example illustrates what can be done with adequate control and good management on timbered lands. Areas on the outside range require from 3 to 4 times as many acres to support each animal as do similar types on the experimental range. The number of cattle that have been grazed over the 17-year period have varied widely on the outside, losses have been far greater, calf crops have been much lower, the cost of producing calves has been greater, and their sale value less than on the experimental range.

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[3] Pickford, G. D. The Influence of Continued Heavy Grazing and of Promiscuous Burning on Spring-Fall Ranges in Utah. Ecology, v. 13, no. 2: 159–171. 1932.

Depletion of the under-story vegetation had reached such a serious stage and soil erosion had become so active on local areas of the woodland and brush types before creation of the Tonto National Forest that, even with regulation of grazing for the past 27 years, it has not been possible to arrest the deterioration. The seriousness of such depletion is evident when it is realized that the continuing erosion is greatly adding to the silt problem of the Roosevelt Reservoir, the principal storage basin of the Salt River reclamation project in Arizona.

The governor's special flood commission[3a] concluded that the destructive floods of northern Utah in 1923 and 1930 (and which have continued in 1931 and 1932) were largely the result of the depletion of the vegetation on critical parts of the mountain watershed largely through overgrazing and fires and to some extent overcutting of timber. The evidence, from further intensive cooperative study of the cause of these floods by the Utah State Land Board and the Intermountain Forest and Range Experiment Station, points directly to denudation of relatively small areas on private lands near the headwaters of the affected streams. The damage in this heavily populated part of Utah has amounted to well over $1,000,000 and several lives have been lost.

On the Kaibab National Forest and Game Preserve, depletion from overgrazing by game has become pronounced. The 1931 investigative committee made up of representatives of several national conservation, wild life, and livestock associations, and Federal and State agencies, concluded that the area is not now producing more than 10 percent of the nutritious forage that it once supported. Although the numbers of domestic livestock grazing on the area in 1913 have been reduced about 85 percent, the large increase that has occurred in the mule deer population is causing a continued deterioration of forage, especially on the winter range, which has meant starvation losses among the deer.

MANAGEMENT PROBLEMS

The conditions on western forest ranges as cited above show the definite need for development and application of management that will, through rehabilitation of the valuable subordinate forest vegetation and stabilization of range use, permit effective coordination of grazing with the watershed protection, timber production, recreation, and wild-life services of forest lands. Restoration of depleted forest ranges would ultimately not only benefit the livestock owners, but contribute to more satisfactory watershed protection, aid in protection of timber reproduction from grazing damage, and make available more abundant feed for wild life.

[3a] "Torrential Floods in Northern Utah, 1930." Report of Special Flood Commission. Utah Agr. Expt. Sta. Circ. 92. 1931.

RELATION OF GRAZING TO OTHER FOREST RESOURCES

Soil is the basic forest-land resource. The retention of the fertile humus layer of top soil is essential to continued productivity. This depends on satisfactory maintenance of the protecting plant cover. In their original condition the forested slopes and valleys, except on a few areas of very unproductive soil, were well covered with dense forests or open tree stands and an under story of herbaceous and shrubby plants. This cover, together with its litter of decaying vegetable matter, had built up the surface soil into a friable condition, added to it a large quantity of rich organic matter, protected it from beating rains, and maintained it in a condition for maximum penetration of precipitation. The result was that the forest cover prevented excessive run-off or abnormal erosion. Through conservation of precipitation the productive soil yielded abundantly.

Overgrazing as well as fires set in an effort to improve forage have seriously depleted the herbaceous and shrubby vegetation and the litter on extensive areas of practically all forest types. Heavy rains falling on such exposed soils have started erosion which has stripped away much of the fertile surface layer. On an important portion of the Boise River watershed in Idaho, for example, depleted by past overgrazing, a survey by the Forest Service disclosed that only 35 percent of the grazed forest and brush types had escaped erosion. On the eroded portion a large part of the upper soil layer has been lost by widespread sheet and gully erosion. Six inches or more of the rich topsoil has also been lost from large areas of such important watersheds as the foothills of the upper San Joaquin Valley and the mountains of central Utah. The raw subsoil remaining is incapable of producing the plant cover the land once supported. Years of careful management will be required to restore the soil and vegetation, yet this must be done if the accelerated erosion is to be controlled.

It should be clearly understood that this loss of soil productivity by erosion following improper range practices affects not the stockman alone but the general public quite as deeply. Loss of productivity of the range resource, if allowed to proceed unchecked, removes taxable wealth and possibilities for current income, thus directly affecting community welfare. Furthermore, rapid run-off from depleted slopes, especially that from rainstorms, and the erosion debris which it carries increase the destructiveness of floods, and add greatly to the silting problem of reservoirs and of other irrigation works in the West. For example, an official of the Indian Service reported[4] to Congress that the Zuni Reservoir in New Mexico had in 22 years filled with erosion debris to over 70 percent of its capacity, practically destroying its usefulness. The heavy investment in irrigated farm lands, in irrigation and power properties, and the urban values built up by these developments far outweigh the values represented in the livestock enterprise dependent upon the watersheds. Farm land values in the Boise irrigation project alone of over $53,000,000 are equal to $31 for every acre of the watershed. The public therefore, is vitally concerned in the condition of the watersheds.

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[4] Hearings before Subcommittee of House Committee on Appropriations on Interior Department Appropriation Bill for 1931, 71st Cong., 2d sess., pp. 304–305.

The importance of improving the vegetative cover is strikingly shown by Forsling[5] in a study of two small subalpine watersheds in central Utah. On one the vegetation has been maintained since 1915 with a cover of about 40 percent of the soil surface. The other supported a cover of only 16 percent from 1915 to 1920. This cover was increased, partly by artificial reseeding, to 40 percent where it was maintained from 1924 to 1929. Over 95 percent of the annual surface run-off came from melting snow. Such run-off is the main supply for irrigation, supplemented by a delayed drainage of percolated snow water extending through the summer. Surface run-off from summer rainstorms on the watershed in depleted condition (1915 to 1920) swept away over 8 tons of sediment per acre, or for at least 3 years of record about 85 percent of that removed yearly. After improvement (1924 to 1929) the sediment removed annually by summer rainstorms was only about 1 ton per acre. For the periods 1915 to 1920 and 1924 to 1929 the difference between the two watersheds in surface run-off per inch of total rainfall was 0.042 and 0.011 inch, respectively, and in sediment removed per inch of rainfall, 21.8 and 2.8 cubic feet. Thus, as a result of improvement in the vegetative cover, a considerable reduction in the relatively small surface run-off from rainstorms was accompanied by a marked reduction in erosion.

On depleted areas of important watersheds, therefore, it is not sufficient simply to maintain a thin stand of vegetation. Management should be adjusted to facilitate as rapid recovery as is practicable. Although grazing can usually be adjusted through improved range management to meet watershed-protection requirements, there are areas within watersheds from which vegetation has been almost denuded or on which the natural balance is so insecure that any grazing in an effort to secure the negligible quantity of feed available would cause undue sliding of soil and prevent new vegetation from becoming established. Grazing should be excluded from such areas, at least until enough vegetation has been established to check the extreme erosion of soil from the slopes.

Large areas of western forest land are used for furnishing municipal water supply. The extent of such use is indicated by the fact that about two and one-half million people, living in over 700 cities or towns in the Western States, obtain their water supplies from areas within national forests. A pronounced public sentiment exists against the grazing of livestock, and especially sheep, on watersheds from which domestic supplies are derived. Sanitary engineers, however, hold that danger of contamination is not from the livestock but from the presence of human beings on the watersheds. Thus, the Washington State Board of Health, after an investigation of the watershed furnishing Walla Walla with its domestic supply, advised the city that removal of all stock would not insure purity and that filtration was the only practical way to bring this about. The United States Public Health Service in reporting on this case stated: "States have not passed laws to prohibit grazing on watersheds, because it is generally agreed among sanitarians that diseases are not transmitted by water from animals to man." Nevertheless in many instances, the Forest Service has entered into special agreements with municipalities for the more complete protection of their domestic supply of water from diminution or contamination, and grazing has been eliminated from about 720,000 acres of watershed lands on national forests for this purpose.

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[5] Forsling, C. L. A Study of the Influence of Herbaceous Plant Cover on Surface Run-off and Soil Erosion in Relation to Grazing on the Wasatch Plateau in Utah. U.S. Dept. Agr. Tech. Bul. 220. 1931.

Ordinarily, serious damage to timber reproduction will not result from range management that is entirely satisfactory from the standpoint of the maintenance or restoration of the forage resource on western forest lands. Overstocking of the range as a whole, too great concentration of livestock on local areas, and grazing after forage has become coarse, dry, and of low palatability, or before new succulent growth has started in the spring, is apt to result in unwarranted damage to timber reproduction. The damage from grazing may become more of a problem where the sprouts and other growth of hardwood species are browsed readily, as for instance, commercially used aspen in Utah.

Where climatic conditions are rather unfavorable to establishment of timber reproduction, damage from grazing may be important. For example, the half million acres or more of timberland in the Southwest, on which satisfactory timber regeneration has been prevented or retarded by improper grazing, call for research to determine specifically how timber and grazing use may be best combined and adjusted to each other. Drought, and long periods between the combination of a good seed crop and favorable weather necessary for seedling establishment, are such serious obstacles to regeneration of the forest that grazing damage, which would otherwise be a small or even negligible amount, becomes important.

Studies by the Southwestern Forest and Range Experiment Station have shown that on cattle range in northern Arizona 27 percent of all the reproduction advanced beyond the seedling stage had in 5 years shown some damage from grazing and part of this had been browsed recurrently. During the first 2 or 3 years of the existence of seedlings, 6 percent were injured and 1.3 percent were killed. On sheep range 9 percent of the advanced reproduction was injured during the 5-year period. Of 2- and 3-year-old seedlings, 7 percent were injured and less than 2 percent killed. Injury to advanced reproduction largely takes the form of retarded growth. This together with the comparatively small seedling mortality from grazing may be the overbalancing factor preventing satisfactory regeneration of the forest, as in this instance, where at least 45 percent of the year-old seedlings and over 15 percent of the 2-year-old seedlings died from natural causes. These studies also indicated, irrespective of whether the range forage was depleted or overutilized, that lack of water or succulent forage is apt to increase the grazing of terminal shoots in dry periods. Evidently under these conditions livestock satisfy their thirst in part by browsing the succulent new pine shoots.

Studies by the Forest Service have shown that livestock should not be placed on summer forest ranges on areas in need of regeneration until the forage has made a good start and should not be left on the range after the more palatable plants are utilized. Sheep or goats should not be bedded or allowed to shade up in areas of timber reproduction, nor be driven through such areas in a close or compact band. Open herding and 1-night bedding grounds for sheep grazing and a close approximation to this in handling goats will help materially to keep damage to a minimum.

As shown in the section on "Wild Life A Forest Resource", the game and fish supported by forest lands and streams provide sport for hundreds of thousands of hunters and fishermen. Forests harbor a large proportion of the commercially valuable fur-bearing animals. They add materially to local business by expenditures of sportsmen and to State and county revenues from the sale of licenses. In addition to the wild life, the forest has educational and esthetic values which cannot be expressed wholly in terms of dollars and cents.

There is much forest land available for wild life which is too rough, supports too dense a stand of timber or brush, or is otherwise unsuitable for grazing by domestic livestock. On most forest lands grazed by livestock, however, there are or eventually will be problems of coordination and adjustments between wild life and domestic animals. The greatest difficulties so far have come in areas overstocked with domestic animals or with game or both, as on the Kaibab Plateau. Likewise an excess of elk south of Yellowstone Park during winter months has made heavy feeding of hay necessary to prevent losses. In general, there is ample summer range on western forests for present numbers of game animals, and in some cases for increases, without conflict with domestic livestock. Winter range on the other hand is insufficient on most areas even for present numbers.

Stockmen as a whole have as much interest in the maintenance of wild life as any other group of citizens. The interest of the public in a large and well-maintained wild-life supply may require curtailment or even elimination of domestic livestock grazing from limited areas of public-forest ranges. Thus, on national forests nearly 3 million acres of usable forest range have been closed to grazing by domestic animals for the benefit of game. Such feed reservations are in addition to the large areas of forest land unsuitable for livestock grazing which are usable by game animals.

Although a large part of the recreational values of forested lands are free to the millions of people who annually enjoy them, additional taxable wealth is created through the development of such facilities. Most of the western national parks are in forested areas, and thus large acreages have been set aside for the sole purpose of recreation and inspiration. From these parks grazing is practically eliminated. This is largely true on the forest areas included within State parks. On limited areas of national-forest land there is a heavy concentration of recreational use, especially such areas as those near Pike's Peak and Mount Hood, where literally hundreds of thousands of people visit the forest each year. Recreational needs for camp grounds, summer-home sites, and other cultural development may also lead to demands for local modification of range use. Such recreational use has brought about elimination of grazing from approximately 1,335,000 acres of usable forest ranges, usually in small units. Some owners of private-forest land have taken advantage of recreational opportunities and have made necessary adjustments in grazing.

Many unreasonable demands have been made by recreational enthusiasts for curtailment of grazing use on extensive areas of public-forest land where all things considered there is no conflict between such use and public interest. Horses and cattle, as well as shepherds with their flocks, on forest ranges are by many people considered an additional scenic attraction.

REVEGETATION

The restoration of depleted ranges to a well-vegetated condition is of the utmost importance. It is essential to more effective and stable livestock production, to more adequate protection of watersheds against abnormal run-off and erosion, and to assuring feed for wild life, as well as to enhancing other forest values.

Affording the native vegetation an opportunity to improve in stand is the most feasible means of restoring forage productivity on large areas of depleted forest ranges. On relatively small areas artificial reseeding would appear practicable. In order to assure range restoration of the important palatable species they must be allowed to develop sufficient growth to regain their vigor and to provide for reproduction either by maturing seed or by other methods of revegetation characteristic of some species. In extreme cases this must be brought about by total exclusion of grazing. However, except where grazing on a very badly depleted area would endanger watershed values it is seldom necessary to exclude livestock if grazing use is properly adjusted to the needs of the important palatable plants on the range. Such adjustments ordinarily will restore the plant cover as effectively as leaving the range ungrazed.

Of the several methods of revegetation developed by research in the Forest Service, deferred and rotation grazing has proved to be a very effective low-cost method applicable to many western range conditions. Simply stated, it consists of deferring grazing on a part of a range unit each year until the more important palatable forage plants have matured a vigorous growth and, where reproduction is by seeding, have matured seed. The rotation feature comes in through deferring grazing for a year or two on different parts of the unit in succeeding years. By such late fall use the mature seeds are shaken to the ground where they may be partly buried by trampling. During the following year light grazing or deferred use again may be desirable in order to promote establishment of seedling plants. On the average, ranges thus grazed for 10 to 15 years gain about 20 percent or more in forage value. Certain areas in central Utah have increased 50 percent, and some test areas 200 to 500 percent.

The more valuable forage species are so badly depleted on some areas that natural revegetation will take at best many years. On areas having favorable soil and moisture conditions and a thin stand of native vegetation, such as depleted mountain meadows and moist parks, and also on deeper alluvial soils rich in organic matter, sowing of seeds of the better cultivated forage plants and of desirable native range species, may greatly speed up restoration. In Ephraim Canyon on the Manti National Forest in Utah, for example, studies of the Intermountain Forest and Range Experiment Station have shown that the native wheatgrasses and brome, and the tame crested wheatgrass, Kentucky bluegrass, and smooth brome, among others, have tripled the grazing capacity of small test areas in openings within the forest. However, where the rich top layer has been lost the soil is unable to produce high yields, and although increases in forage production up to 25 or 35 percent were obtained, increases beyond that point will doubtless be slow until productive soil is again rebuilt. Several cultivated forage plants have given good results in extensive tests on favorable sites in the central and northern Rocky

Mountains and in the Pacific Cascade slopes. The forest range areas suitable to reseeding are individually small but total a considerable acreage as a whole. Reseeding ordinarily costs several dollars an acre. For range use alone it may not pay as compared to the slower natural revegetation. In the section of this report "A Watershed Protection Program", the need is pointed out for the early revegetation of about 900,000 acres in order to more adequately protect important watershed areas against undue run-off and erosion. As research develops cheaper and more effective methods, it is probable that artificial reseeding will take a more prominent place in plans for revegetation.

Selection and hybridization of range forages offer one of the greatest ultimate opportunities in revegetation if this work is undertaken in a comprehensive way to unite aggressive spreading habits of downy brome, for example, with the desirable forage habits of mountain brome. Such research is badly needed.

PRINCIPLES OF MANAGEMENT

In the administration of western forest ranges to bring about the proper coordination of grazing with other forest uses and the restoration and maintenance of the forest understory, there are four main underlying principles which should form the basis for plans and procedure. They are: (1) Use of the range by the class of livestock best suited to use it. (2) Adjusting the number of livestock to what the range can support satisfactorily on a permanent basis. (3) Adjusting the season of use to the most satisfactory period from the standpoint of correlating maintained feed production with greatest value from the use of the feed. (4) Distributing the grazing over the range in such a manner as to reduce damage around natural congregating places, to insure even utilization of all parts, to facilitate use of feed of particular value at certain seasons of the year, and to protect parts of the range needing special attention.

CLASS OF STOCK TO WHICH RANGE IS BEST SUITED

While the class of stock grazed on forest range will largely be governed by the present class grazing the range, by economic conditions, or by likes or prejudices of the particular owner, the trend should be toward the class or classes which can best utilize each particular range area. Cattle are attracted to open timber or woodland areas and grasslands or meadows in openings in the forest. They can be induced to utilize rather steep timber or brushy slopes, but the attempt to obtain a satisfactory degree of use of such areas is apt to result in overgrazing the more level and more open areas where cattle tend to congregate.

Sheep prefer a mixture of luscious grasses and weeds, and these are essential to the best development of lambs. They utilize open range to advantage and will penetrate and utilize areas of rather dense timber or brush. Usually they graze steep slopes more thoroughly than do cattle.

The advantage of adjusting class of stock to the range utilization possibilities is well illustrated by a national forest range in central Utah. This area was badly depleted before the creation of the forest but under use by cattle made slow improvement during the first 15 years of Forest Service administration. To correct the overgrazing prevalent in the local open valley areas and to speed up recovery would have required such heavy reductions in the number of cattle as to make further grazing by that class alone uneconomic. In 1922, owners of part of the cattle grazing on the range were permitted to replace them by sheep, and further changes were made later. As a result, the sheep have made better use of forage on the slopes and have been held off the open valley areas. The heavy grazing by cattle on the spring range and in the previously overgrazed valleys was practically eliminated. The spring ranges have improved from 100 to 200 percent and depleted parts of the summer range have improved as much as 400 to 500 percent. A more profitable basis of use of the range was developed and better watershed protection was afforded as a result of the improvement of the protecting vegetation on the depleted areas.

On areas in Texas, Arizona, and Utah, supporting a considerable quantity of browse there has been a tendency toward an increase in use by goats. If goats are grazed in reasonable numbers they can use many browse ranges to advantage where grazing capacity for cattle is so low that it is difficult for that class to be grazed satisfactorily.

NUMBERS OF STOCK WHICH THE RANGE CAN SUPPORT

One of the greatest and most widespread causes of range depletion has been overstocking. Too often stockmen have been tempted to obtain reasonably full use of an abundance of low-value species on their ranges, with the inevitable result that high-value forage was badly damaged or eliminated. An example of this is the efforts to obtain rather heavy use of oak brush on ranges of southwestern Utah grazed in summer by cattle. An experiment by the Forest Service on this type of range showed that under more conservative grazing, although fewer animals are grazed, these will yield a higher return than would a larger number of animals crowded onto the range.

The only safe basis of judging grazing capacity is the proper utilization of the more important palatable forage plants of each range area. In the West, as a whole, the main feed on forest ranges is furnished by bunch grasses, some succulent weeds, and a few browse plants that are of moderate to high palatability. Ordinarily average utilization of approximately 60 percent of the foliage production each year is as close use as these plants can withstand and maintain their vigor, although a few plants will withstand utilization up to 80 or 90 percent of their foliage. Use of all the foliage of the main forage plants robs them of their food-making parts and upsets their ability to compete with the lightly grazed vegetation. Such use leads to reduced grazing capacity and may result in rapid deterioration of range values.

There is a considerable difference in the quantity of forage produced in good years and in years unfavorable to plant growth. If stocking is based upon average forage production rather than upon the occasional very high forage yield, the intermittent years of poor plant growth can often be tided over without unwarranted injury to the range.

Precipitation is extremely important in forage production on forest ranges. Studies by the Forest Service of precipitation in relation to growth of vegetation in different parts of the West indicate that below-normal conditions have prevailed on the average over much of the range during the last 8 to 15 years. Thus in the foothills of the San Joaquin Valley of California precipitation for the period from 1923 to 1931 was about 14 percent below normal; precipitation at Boise, Idaho from 1919 to 1931, inclusive, was below average in 9 years out of 13; while at Roosevelt, on the Salt River watershed in Arizona from 1922 to 1930, inclusive, 6 years were well below average and 3 years were only slightly above average. Such continued subnormal precipitation, in a naturally semiarid region, makes it extremely difficult for the vegetation to maintain itself. If stocking is not adjusted currently to reduced forage production, rather serious depletion results. For example, on woodland ranges of southern Idaho, largely in private ownership and in the public domain, results from measured plots have shown that the forage cover has been reduced from 40 to 80 percent of the original cover over large areas.

On national forests, where an effort is made to adjust numbers of livestock to average feed production over the years and thus prevent overgrazing, the large increases in numbers of livestock during the war, as an emergency measure, resulted in overstocking on many national-forest ranges. It has been difficult, in view of the subnormal precipitation, to reduce stocking rapidly enough to check range depletion. Where voluntary reductions were not sufficient it has been necessary to require reductions in the number of livestock. Fortunately, such required reductions have not been great or widespread.

PROPER SEASONAL USE

Grazing forage plants before they have made enough growth to withstand cropping has also been one of the principal causes of the deterioration of western forest ranges. If grazing promptly removes the first growth it deprives the plants of their food-making parts. As a result, the vitality of the forage plants is lowered, forage production is reduced, and the weakened plants are unable to produce fertile seed, or may be killed out entirely. Therefore, the date when grazing can satisfactorily begin should be based upon the development of the more important palatable plants on the particular range. With sufficient growth, utilization of part of it will not injure the vigor of the plants.

The close of a summer-grazing period should be governed usually by weather conditions and by the supply of feed. It is not advisable, as a rule, to graze the range in the fall up to the point that livestock can get only enough forage for sustenance.

PROPER DISTRIBUTION OF LIVESTOCK ON THE RANGE

Adequate distribution of watering places and salt offer the most practicable and economical means of procuring satisfactory distribution of cattle and full and uniform use of available feed.

Examples of beneficial results from more effective distribution of cattle on national-forest ranges are numerous. While in most instances the main result has been to overcome local overgrazing without reducing the number of cattle, one national forest supervisor, for example, reports an increase from 1,574 cattle to 2,200 on one range in 7 years as a result of some 66 new, well placed salt troughs. Another reports an increase of from 800 to 1,300 cattle in 3 years by additional water development and the application of proper salting.

It is much simpler to obtain satisfactory distribution with sheep since they are continually under the care of a herder. The open-herding and bedding-out system of handling sheep, developed by the Forest Service from studying sheep grazing in pastures and through experimental tests of herding throughout the West, provides for quiet grazing in open formation during early morning and evening, a minimum of trailing and use of dogs, and bedding on a new ground every evening. Its advantages compared to the old bedding and herding systems are: (1) More even utilization of the forest understory, permitting more satisfactory maintenance of cover for watershed protection over the whole area grazed; (2) less heavy local damage to timber reproduction; (3) an increase in grazing capacity of 20 to 25 percent; (4) cleaner and larger wool clips are produced; (5) a greater average weight of lambs; and (6) great reduction in losses from poisonous plants. Thus there is a direct benefit to the stockman as well as to the range.

OTHER FEATURES OF FOREST RANGE MANAGEMENT

In the development and application of sound forest range management, properly coordinated with other forest uses, the following items need consideration: Range improvements and the control of poisonous plants, rodents, and predatory animals.

As better range management has been perfected, increasing attention has been given to the development of such range improvements as fences, water developments, driveways, pastures, corrals, and other equipment and developments for controlling grazing so as to obtain most satisfactory utilization of the forage. Often boundary fences are the only practical means of eliminating trespass and keeping stock within allotments, of dividing ranges for seasonal use, or segregating classes of livestock. Water is an absolute essential to effective use of the range. It is not abundant on many ranges of the West, particularly in the Southwest; therefore, it is necessary to drill or dig wells, construct reservoirs for catching run-off water, to improve springs, and to pipe water into troughs sufficient for watering all the livestock that should water at one time. Driveways and trails, bridges across swift mountain streams, riders' cabins, and other improvements also facilitate the handling of livestock and otherwise aid in range management that is needed for the fullest correlation of grazing with other forest uses.

In 1930 it was estimated that 5,414 cattle and 24,883 sheep were lost on the 1,300,000 acres of national-forest land known to be infested with poisonous plants. At conservative low price figures, this loss exceeded $250,000. Over one half of the cattle losses are attributed to larkspur poisoning. Grubbing, at an average cost of about $5 per acre, generally is an effective control measure for exterminating this weed. Grubbing a relatively small area may release a whole range from danger for several years. Chemicals have been used effectively to kill larkspur but cost more than grubbing.

Water hemlock and death camas may also be controlled by grubbing. It is thought, however, that the real remedy in many cases must be the indirect method of revegetating the range and maintaining a liberal supply of the more valuable forage. Properly placed drift fences on infested cattle ranges and quiet herding on sheep ranges may serve as makeshifts until the more permanent remedies of eradication of the poisonous plants or range revegetation may be provided.

The presence of rodents on many of the forest ranges reduces seriously the subordinate vegetation needed for watershed protection and forage. The Forest Service estimates conservatively that on more than 15 million acres of rodent infested range in the national forests, including 5.8 million acres already treated, the grazing capacity is lowered fully 10 per cent by the destruction of forage plants and by the consumption of current growth.

The more serious aspect of rodent damage is the destruction of the protective vegetative cover of the soil, accompanied by a stirring up of the surface soil which exposes it to erosion. Unfortunately this sort of damage is most pronounced and serious on many areas where originally the soil was deep and highly productive.

The Bureau of Biological Survey, in cooperation with stockmen and the Forest Service, has done very effective work on many national forests, particularly in Colorado, Arizona, and New Mexico. The ranges cleared of rodent pests have shown improvement, but follow-up measures and continued extension of control work are necessary if permanent beneficial results are to be obtained.

Stockmen suffer serious losses every year from predatory animals, especially coyotes, wolves, and mountain lions. There are also heavy losses in game animals. The Bureau of Biological Survey is conducting a control campaign upon predatory animals, cooperating with State authorities, the Forest Service, and stockmen. While excellent results have been realized, it has been impossible with the funds available to cover fully the vast area of country infested.

It is the policy of the Department of Agriculture to control rather than to exterminate predatory animals. Many people believe that predators largely offset their damage to livestock where they contribute substantially to rodent control. Predatory animals are recognized as an important consideration in game management. Where surplus game animals cannot be utilized in beneficial ways control of predators may be lessened. Where the reverse is true control measures become a necessity to the maintenance of a proper balance between predators and game species.

THE SITUATION IN DIFFERENT OWNERSHIPS

The basic conception at the present time for use or disposition of forest ranges varies so widely between those public and private agencies owning such lands that distinctly different situations have developed. On the national forests the principle of multiple use of all resources for the benefit of local communities and the public prevails; but on the unreserved public domain, although Federal ownership implies an equal obligation in the public interest, there is an utter lack of policy either in use or regulation. Western States ordinarily aim to obtain as much revenue as possible from their forest ranges regardless of conservation of the resources. The chief concern of the private owner is to make a profit from his land. A review of each of these situations and the results of each is, therefore, warranted.

On publicly owned and managed forest ranges the method of disposing of the forage varies considerably. Range feed is sold either on a per head or per acre basis, although the latter method is likely to encourage abuse of the range for immediate gain, unless the proper stipulations as to number of stock and seasons are incorporated in the lease. The grazing fee may be established either from competitive bidding or from an appraisal of the individual range unit which recognizes the priority of the established user. The fee based on appraisal, when fixed on a reasonable basis over a period of years, undoubtedly tends toward stability of range use, but experience has shown that it is subject to pressure for reduction.

The competitive-bid basis produces a larger cash return to the landowner and seems largely to eliminate the grounds for agitation for fee reduction, but requires very careful supervision to avoid the tendency to overgraze the range in an effort to pay out on the higher fee at the expense of future range productivity. It also tends to work against continuing use of a range unit by the same stockman and thereby lessens his interest in sustained range productivity.

NATIONAL FORESTS

The aim of the administrative policy of the Department of Agriculture in handling the 64 million acres of forest ranges within the western national forests is to obtain as fully beneficial use of the various resources of the land as is consistent with their permanent conservation. This concept, which lays stress on land management and on the use and perpetuation of the resources in place of reservation for the future, came in 1905 with the transfer of the then "forest reserves" from the Department of the Interior. Consistent with conservation and use of the timber, watershed, wild life, and other resources, the aim of the range policy on the national forests is (1) to build up the forage resource and its productivity through the development and introduction of the best possible methods of management, and (2) to promote a stable and prosperous use of these resources by permanent settlers on or adjacent to the national forests and dependent upon the use of forest ranges for satisfactory development of their own lands and livestock businesses.

No actual rights accrue to the stockmen using national forests, although they hold preferences for the use of range for certain numbers of livestock. These preferences have come to have considerable stability and, subject to the approval of the Forest Service, may be transferred upon the sale of ranches or livestock or both.

Grazing privileges within the national forests are not sold at competitive bid as is the common practice in disposal of timber. The range feed is disposed of on the basis of a reasonable fee determined after careful consideration of the forage available, accessibility, and other phases of use. In 1931 the average fee for cattle was 14.5 cents per head per month and the average fee for sheep was 4.5 cents per head per month. In 1932, because of the emergency conditions created by the 1931 drought followed by a severe winter, the fees were reduced by 50 percent by grant of the Secretary of Agriculture and the President.

Range management plans have been prepared for national-forest units. They are based upon the principles of forest-range management already outlined, and are administered so as to carry out the national-forest objectives.

The degree of success attained in the past 28 years in accomplishing the above objectives by means of the permit system on a per head basis is noteworthy. The improvement in condition of the range resource during this time, although it has not been uniform, is on the average marked. This in turn has furnished a corresponding improvement in watershed-protective values and in conditions favorable for wild life. Improved forage conditions also are of considerable value in sustained livestock production on national-forest ranges.

A discussion of grazing on national forests is presented in this report under "The National Forests."

INDIAN RESERVATIONS

The objective of Federal management of grazing on the 12 million acres grazed of the 14 million acres of commercial and noncommercial forested lands (including 6.7 million acres of piñon-juniper type) within the Indian reservations is to obtain the maximum benefit for the Indians. In carrying out this objective the Federal Government aims to obtain a maximum revenue for the Indians, insofar as it is possible, and perpetuate the range resource. A grazing plan has been or is being formulated for each Indian reservation. In connection with this, provision is first made for Indian-owned herds, range not needed by the Indians being leased under a system of competitive bids to the local stockmen. These leases run for periods of from 1 to 5 years. Leased lands are either (1) lands allotted to individual Indians, or (2) unallotted tribal lands.

The revenues obtained for lease privileges vary with the demand for and the condition of the range. They have been on the average 16.9 cents per head per month for cattle and 7.3 cents per head per month for sheep.

PUBLIC DOMAIN

The unreserved public domain contains approximately 21.5 million acres of grazed forest land. This area is the forested part of the land remnant held by the Federal Government after reservations, grants, and private appropriations have been made. It is a free range open to whatever grazing use individuals may make of it. The serious conditions on it reflect the absence of management. A rancher must graze the range near his property as heavily as possible, from early spring till late fall, or year long if in the region of mild winters, in order to avoid having someone else crowd in on him. During the summer growing season "tramp" herds may closely utilize feed that should, for the best interests of the industry as a whole, be reserved for winter. Such herds often come in and profit by whatever protection local stockmen have given the range.

It is of the utmost importance, if such range is to be saved from utter destruction, that these forested public-domain areas, as well as the many million acres of nontimbered range land in the public domain, be given a status which will make possible management and restoration.

STATE LANDS

The aim of western States, in handling the State forest land grazed by livestock, of which 4 million acres now remain, has usually been to convert the land into cash by sale or to obtain the greatest possible cash income from leasing. Much land formerly held by States has been sold to any who would purchase, frequently to the highest bidder at public auction. Two bad results have arisen from this plan. In some cases the land has brought so little that it was virtually a gift to the purchaser. In other cases because of the anxiety of several stockmen, some of them transient, the price bid was so high that it was never paid and the land after being badly abused reverted to the State.

Leasing for the largest obtainable cash return has meant in most cases competitive bidding, whereby the previous lessee had no assurance that he would have continued use of the land. In some States there is provision for protecting the interests of the previous resident lessee, although he may have to increase his rental to meet a higher bid. Under great necessity to obtain a certain area, a stockman might be forced to meet an unreasonable bid, perhaps by an alien who bid very high in order to get a local foothold, often with the idea of extending his grazing to other lands. There are seldom any provisions as to how the range shall be grazed or any field supervision and ordinarily the stockmen use it as they deem best. Lack of provision for adequate management in disposal or lease makes for lack of assurance of permanency, and in some cases State lands have deteriorated until they correspond closely in condition with the unreserved public domain.

PRIVATE FOREST RANGE LANDS

Nearly 42 million acres of privately owned forest land in the West is grazed by livestock. More than 15 million acres of this area is in farm woodlands, according to the 1930 census. The remainder is in larger holdings mainly owned by stockmen, lumber companies, or other corporations. Holdings of stockmen are chiefly in noncommercial forest types. While the majority of private owners use their forest ranges with the expectation of continuing grazing use, they fail to appreciate what is happening to the range under the heavy use commonly practiced. Little concern is given to the timber and other resources. The major objective is maximum income. These ranges, as a whole, have declined in grazing capacity to a condition almost as bad as that on the public domain. There are of course individual privately owned ranges that are well managed and on which forage, timber, and watershed-protective conditions have been well maintained. Occasionally forest range lands owned by railroads and other corporations are leased under definite stipulations as to the manner and degree of use, but this is the exception. In the numerous cases where such stipulations are not made the result is nearly always serious depletion of the range.

A considerable part of the private land within the national forests is turned over to the Forest Service to be managed under the same plans that apply to adjacent Government land. Such land is ordinarily kept in reasonably good condition.

FOREST RANGES IN THE SOUTH

The forests of the South furnish considerable feed for livestock, particularly for cattle during the spring and early summer. The region here considered is identical with that presented in "Forest Land the Basic Resource" section, and extends from Texas, Oklahoma, and

Arkansas, through the Gulf and Atlantic coastal States to Virginia and including that part of the southern Appalachians within these States. It is estimated that nearly 150 million acres (table 1) of the 217 million acres classed as forest land is grazed at least to some degree. The commercial pine and hardwood forests have been largely cut over and although they are now mainly in some degree of restocking to forest growth, most of the area supports a good growth of grasses and shrubs suitable for livestock grazing. A large part of the noncommercial forest lands are grazed.

Nearly 15 million cattle, 9 million sheep, and over 9½ million hogs (1930 census) in the region as a whole, are on farms, forest, improved pasture, and untimbered range lands. Texas and Oklahoma together have 8.7 million cattle, 7.2 million sheep, and 2.6 million hogs, a part of which graze on forest lands in the eastern sections of these States. A still larger proportion of the cattle, sheep, and hogs in the rest of the South obtain feed from the forest range. The grazing of livestock on native forage produced on forest lands furnishes a livelihood or supplemental income to a substantial proportion of the rural population and in some instances provides a current return to the landowner to meet carrying charges. Timber growing and adequately controlled livestock grazing seem to represent a dual use which can contribute substantially to economic use of forest lands.

The "Forest Land the Basic Resource" section of this report shows that approximately 98 percent of the forested area in the South is privately owned. Nearly 70 million acres is in farm woodlands, of which, according to the 1930 census, nearly 34 million acres, or almost half, is pastured. It is estimated that about 112 million acres are grazed of the 143 million acres in other types of private ownership, chiefly large holdings of lumbermen and turpentine producers. Of the area in public ownership, amounting to less than 4½ million acres, the largest part of which is in national forests in the southern Appalachians, it is estimated that over 3.2 million acres are grazed. A tax-delinquent situation has developed to such an extent during the past decade that the forest lands reverting to the public for nonpayment of taxes are reaching sizeable proportions.

The forest lands in the South are largely unfenced and are for the most part grazed by livestock of local residents, who seldom own very much of the land they use for grazing their livestock. Furthermore, the leasing of grazing rights on privately owned timberlands is not common practice. In most States these unfenced forest lands are generally considered public ranges, and in the southern pine type commonly are burned annually or periodically by the local livestock owners. The original timber has been largely cut off, so that the peak of forest productivity has passed for the time at least. The practice of annually burning over the grass and other ground cover during the dormant period interferes with satisfactory forest restocking on much commercial forest area.

Much progress has been made in improving livestock-raising conditions and methods in the South through cooperative efforts of the United States Department of Agriculture and the various State agencies. Perhaps the most outstanding accomplishment has been the elimination of the Texas fever tick of cattle from most of the area. As a result, pure-bred cattle have been brought in extensively to improve the type and grade of native stock. The development of improved pastures and supplemental feeds with introduced cultivated forage plants has greatly improved feed conditions on farms. All of these have aided in a more systematic and profitable livestock-raising program. And yet a poor grade of livestock and a care-free type of management still prevails on much of the forest range in the South. The wide extent of forest lands and the large amount of herbage produced offer great possibilities for livestock grazing in conjunction with the growing of timber crops.

FEED PRODUCED ON FOREST LANDS

The principal forest-range types in point of area are the longleaf-slash pine, extending along the lower Atlantic and Gulf coasts, and the shortleaf-loblolly pine-hardwoods type, which forms a wide belt through the heart of the region from east to west. The less extensive oak-pine and oak-chestnut yellow poplar types along the northern edge of the region are grazed but little. Grazing is also light in the river bottom hardwoods cypress type along the Mississippi and other rivers. But the oak-hickory forests, west of the shortleaf loblolly pine-hardwoods type in Texas and Oklahoma, are extensively grazed.

The longleaf-slash pine type is one of the most important stock-grazing areas of the South. Observations by State and Federal agricultural workers indicate that the so-called "wire grasses", including certain andropogons, needlegrasses, muhlenbergias, and dropseeds and broomsedge are among the most important native grasses. Introduced grasses, such as Bermuda grass, carpet grass, Dallis grass, and crabgrass, are well established on limited areas, usually in clearings. They are eaten readily by livestock and often are of great importance as forage. Lespedezas, tick-trefoils, ground nuts, clovers, and other legumes are also common in this region.

The shortleaf and loblolly pine-hardwoods type is rich in botanical species, the most imporatnt from a grazing standpoint including broomsedges and needlegrasses among the grasses, deervetch and tick-trefoils among the legumes, and cottonwood, sassafras, black willow, oaks, and in the eastern portion, yellow poplar, among the species browsed. Tree growth is often so dense in the more southern of the Mississippi River Valley bottomlands as to limit grazing. The canebrakes, however, furnish excellent cattle grazing unless overgrazed or impaired by fire.

The chief timber types in the southern Appalachians are the oak-chestnut-yellow poplar, and, at lower elevations, the oak-pine type. Forest Service and other studies indicate that besides the reproduction and accessible portions of such hardwoods as oak, hickory, chestnut, yellow poplar, and maples, numerous shrubs are browsed. Here also occur a great variety of native woodland grasses, many of which are valuable for domestic livestock. This is the region of greatest development and abundance in this country for rhododendrons, azaleas, and kalmia (mountain-laurel), all of which are highly poisonous to livestock but usually ungrazed. The grassy "balds" or treeless areas of the southern Appalachian Mountains furnish natural feeding places of high grazing capacity for cattle and sheep. The cover of such balds is largely redtop, Kentucky and woods bluegrasses, with a number of palatable sedges.

The noncommercial forests, principally in Texas and Oklahoma, are not only extensive in area but also are used considerably by livestock. The oak-hickory belt in Texas, west of the shortleaf and loblolly pine-hardwood type, usually contains post oak, blackjack oak, and hickory. The accessible tender shoots and sprouts of the tree species (especially on cut-over areas), as well as those of sassafras, persimmon, and other smaller trees are browsed. Among the grasses the needlegrasses, panic grasses, and broomsedge furnish considerable forage.

FOREST RANGE PROBLEMS

Among the more important problems in the grazing of southern forest lands are: The widespread practice of uncontrolled burning to remove unused grass, the serious damage by hogs in rooting out longleaf pine seedlings, and the grazing of sprouts of valuable timber species in the southern Appalachian hardwoods. Another very important problem is the need for a more adequate coordination between the grazing on forest ranges, the use of improved pastures, and supplemental winter feeding.

In a later section, "Protection Against Fire", it is shown that an average of 37,571,500 acres of forest land were burned annually from 1926 to 1930 in the South, mostly on areas where no organized attempt was made to control fires. A large part of these fires occur in the southern pine belt and are mainly set by livestock owners to remove the rough and to keep down the undergrowth. Fires are also set in the belief that they contribute to the control of insect pests, and in some instances to keep the country open for hunting. Many stockmen also burn the forest undergrowth in the belief that the quality of forage is improved. Green,[6] reports substantially greater gains in weights of cattle on burned forest range in southern Mississippi as compared to cattle on an adjacent unburned area.

Forest Service studies show that uncontrolled fires have already caused great damage to southern pine forests, and are especially damaging to turpentined trees, which are seldom carefully protected after the turpentine operations have ended. Uncontrolled fires on forest land kill out pine reproduction and retard the restocking of many tree species, although longleaf pine is particularly resistant to fires. The coordination of grazing use with timber production requires either the prevention or the control of fire to insure the success of forestry undertakings.

In the southern Appalachians burning to improve forest range is much less widespread than in the pine belt of the South. Unfenced forest grazing is of less importance than formerly because, with the better grade of livestock now being raised and fence laws which make the stock owner liable for trespass, more of the animals are being grazed on improved farm pastures. Some sporadic grazing damage to the better tree species such as yellow poplar, oak, and chestnut occurs in the coves and on lower mountain slopes when cattle congregate there.

Studies by the Forest Service have shown that considerable damage is done to longleaf pine reproduction by hogs, which run at large throughout the year. Mast—acorns and nuts from hardwoods along stream bottoms—furnishes a valuable feed for hogs when available. Hogs relish the seedlings and the spongy root bark of longleaf pines, especially in early spring, when the mast becomes scarce, or when they are driven out of the bottoms by high water. They often destroy whole crops of seedlings by rooting them up in their search for food. Longleaf seedlings several years old and sometimes up to 6 feet in height may be killed. Considerable damage may be done even to larger trees by removal of the outer layers of bark from the lateral roots. The ranging of hogs under adequate control can make good use of the forest range during a comparatively long season without serious damage, but wild hogs in large numbers ranging continuously over the forest do not fit into a forward-looking plan for proper management of the longleaf pine forests.

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[6] Greene, S. W. The Stockman's Interest in Protecting Forest and Range from Fire. Proc. Eleventh Southern Forestry Congress. 1929.

The progress in development of improved pastures and forage crops already effected on farm lands by the Department of Agriculture in cooperation with State agricultural experiment stations and extension services is considerable, as shown by the number of publications available on these subjects. The coordination of forest-range grazing with these improved pastures and with supplemental feeding presents an important problem in the South.

In the Pine Belt, for example, the main forest range forage plants make their best growth and are eaten most readily during the spring and early summer. The graphs accompanying Greene's article in the Proceedings of the Eleventh Southern Forestry Congress indicate that steers usually make rapid gains in weight on forest pasture in southern Mississippi from early April through June and part of July, but gain very slowly or even lose weight during the remainder of the year. A number of forage plants used in improved pastures, such as carpet grass, Bermuda grass, and lespedeza furnish good grazing until in October. While it is true that these pastures can be utilized from any time after March or April, the good gains indicated by Greene as possible on forest ranges through July might make it advisable to remove livestock from the forests in late summer and place them on supplemental pastures saved for that purpose. Some stockmen are finding it advantageous to have fields of Abruzzi rye, Italian ryegrass, or winter oats and legumes such as burr and crimson clovers and vetch to use for winter grazing. Where small cultivated areas within the forest can be used for production of these pasture plants and opened for grazing during the period it is desired to use them, livestock might be grazed year-long within the forest.

The 2,700,000 acres of timbered land grazed within the national forests of the South constitute areas, even though comparatively small, where regulated management of the forest-range resource can be developed and demonstrated for those types of which they are representative.

However, with 98 percent of the forest land in the South held in private ownership and with much of the area used for grazing by other than the owners of the land the problem of obtaining the application of more desirable practices is largely one of education. Much intensive study will be needed to develop the most desirable management and effective coordination of timber growing, grazing, and other uses of forest lands.

FOREST GRAZING IN THE CENTRAL, LAKE, MIDDLE ATLANTIC, AND NEW ENGLAND STATES

On the forest lands of the Central, Lake, Middle Atlantic, and New England States grazing is confined almost entirely to farm woodlands. It is mainly a pasture type, as contrasted to the open range type of grazing prevalent in the West and South. The most intensive use of forest lands by livestock occurs in the Central States, but farm woodlands are pastured at least to some extent throughout the whole region.

The area under consideration is so large and the use of the forest lands by livestock offers such diverse conditions in different sections, that few generalized statements are possible. Of the 63 million acres of farm woodland in these regions over 36 million acres (1930 census), or 57 percent, are grazed. There are approximately 106 million acres of forest land in other private ownership, mostly in larger holdings of sufficient size for commercial lumbering operations. These have been mainly cut over. It is estimated that excluding farm woodland there are less than 6 million acres of forest area grazed to any great extent by livestock in these regions.

The grazed forest areas have an important part in the social welfare of the regions. Although they support only a diminishing residue of the original forest cover, they still produce a portion of the wood used in these regions and can be restored to a higher state of timber productivity with careful management. Only in the more open timber stands is sufficient forage produced to furnish a supplemental income of much value to the owners but, on farm woodlands especially, the trees are often used to advantage as shelter for livestock. On highly erosive soils, as shown in the section on "Watershed and Related Forest Influences", these forests have a high watershed-protective value, where the undergrowth and forest reproduction have not been too severly damaged by excessive grazing and trampling. Forests are especially desirable in these States for recreational, educational, and wild life uses. Recreational and wild life values are practically impossible to determine fully in terms of money, but generally are recognized as necessary for the complete well being of both the urban and rural population.

The function of forest pastures in the livestock industry varies considerably in character and value in different parts of this group of forest regions. According to the 1930 census, these regions have a total of over 36½ million cattle, both beef and dairy breeds; 17½ million sheep; and 41½ million hogs. Of these livestock, approximately 59 percent of the cattle, 69 percent of the sheep, and 82 percent of the hogs are in the Central States. A considerable portion of the livestock use forests at some time during the year. In the Corn Belt States—Ohio, Indiana, Illinois, and Iowa—the farm woodlands are so heavily stocked that little forage remains even in the open stands, and their principal value is for shade and protection to livestock. Outside of the Corn Belt, the farms have more open pasture land available and fewer stock; consequently the intensity of grazing in the forests is considerably lessened.

THE FORAGE ON FOREST LANDS

Studies by the Department of Agriculture and State experiment stations have shown that in the Lake, Middle Atlantic, New England, and most of the Central States little real forage is produced in the understory of a good forest. Reproduction and accessible tender shoots of hardwood trees and shrubs may be browsed by livestock, but such use is discouraged or prevented where timber production is the objective. Mast from oaks, hickories, walnuts, beech, chestnut, and pines, where these species occur, is used widely by hogs. As the forests are opened up by clearing or grazing, numerous grasses appear, many of them naturalized introduced species. Studies by the Bureau of Plant Industry show that many of these incoming grasses are very worth while from a grazing standpoint. Where the soil is fertile, the highly valuable Kentucky bluegrass and white clover furnish excellent pasturage; and if the habitat is moist, bent and red top grasses and frequently white clover supply good feed. After continued heavy grazing, these better grasses give way to less valuable grasses and weeds.

The oak-hickory type which forms a wide belt through the middle of the Central States and extends along the southern and eastern portions of the Lake States forested area is extensively grazed. The oak-chestnut-yellow poplar forest, furnishing some browse and mast, occupies a broad belt along the length of the Appalachian Range. The birch-beech-maple-hemlock type extends in a belt mainly through the Lake States well into the northern Middle Atlantic and New England States. On the richer soils of which it is characteristic, naturalized grasses and white clover are locally present and supplement the native herbage.

The spruce-fir-hardwoods type, over most of its range, is usually too dense for grazing except by game. In the Lake States, if the forest is sufficiently open, a number of important grasses occur but the type is now little used by livestock.

The oak-pine type of southern Missouri and on many south-facing hill slopes from southern Ohio to the Southern States supports native grasses and sedges which together with shrubby growth and mast furnish feed for livestock.

FOREST GRAZING PROBLEMS

In the New England, Middle Atlantic, and Lake States forest grazing is almost entirely on farm woodlands. In the Central States it is estimated that approximately 77 percent of forest area used by livestock is farm woodland. In the Lake States, some attempts have been made to graze the forage produced in the understory of the forest, and the herbaceous cover on cut-over hardwoods, spruce-fir, and the pine forests, but little success has been obtained. Forest grazing problems at present, therefore, are confined almost exclusively to farm woodlands.

The need for coordination between grazing and timber production on farm woodlands is becoming increasingly important on many areas, especially in the Central States. Damage to timber reproduction is especially serious in the Corn Belt, in spite of the fact that the real feed for the livestock grazing in woodlands is produced on the farms from cultivated forage crop plants and on improved pastures. Estimates by the Central States Forest Experiment Station show that the woodland pastures of the Corn Belt are being used by at least 5 times as many livestock as the grazing capacity of the herbaceous and shrubby vegetation would support. The principal effect of this overgrazing on the farm woodlands is the retardation, deformation, and usually the complete elimination of timber reproduction between the heights of 6 inches and 12 feet. This, combined with the death and occasional cutting of mature timber, is rapidly converting the woodlands of the better agricultural sections into open pastures.

Overgrazing of farm woodlands in the Central and Northeastern States is ordinarily detrimental to watershed values of the forest. For instance, studies by the Central States Forest Experiment Station in the farm woodlands revealed the marked effect of grazing upon the depth of litter and humus. On 87 plots in the oak-hickory type, ungrazed plots had an average depth of litter of 1.8 inches; lightly grazed, 1 inch; moderately grazed, 0.7 inch; and heavily grazed, 0.4 inch.

The average depth of humus on the plots under the grazed conditions in the order named above was 0.5, 0.3, 0.2, and 0.1 inch. The top 9 inches of soil was found to be 15 percent heavier and more compact in grazed then in ungrazed woodlands. As shown in the "Watershed and Related Forest Influences" section of this report, litter, humus, and soil porosity are important for conserving precipitation and preventing undue run-off and erosion.

If timber production appears to be the best source of income, grazing should be adjusted to protect forest reproduction and assure future timber crops. To continue to use entire woodlands on many farms so heavily that timber reproduction is seriously damaged would hardly appear best from either the standpoint of timber production or most effective farm-land use. At least 1 million acres now classed as commercial forest, mainly in the Corn Belt, should be considered as primarily valuable as shade and shelter for livestock, and so withdrawn from the area of commercial forest. This acreage would be made up of a great many small units, doubtless of a few acres at most, on individual farms where a part of the present grazed woodland would be fenced off for livestock. From a forestry standpoint it would be best if grazing were eliminated from the balance of the woodland. Where grazing is continued in farm woodlands held for timber production, it should be limited to the actual feed available, so that undue damage will not be done to the timber reproduction and forest litter. The fundamental consideration in the use of forest pastures in these regions is primarily one of economic values. The whole situation demands further study of coordination of grazing with timber growing and other forest-land uses and an adequate program of extension and education to apply the practices developed.

MINOR BY PRODUCTS OF THE FOREST

By W. A. DAYTON, in charge of Range Forage Investigations

In order to form an adequate concept of the complexity of the forest community and to understand its full actual and potential importance, it is necessary to realize the enormous number and variety of organisms of which it is composed. In addition to upward of 1,200 species and varieties of trees indigenous to the approximately 600 million acres of forest land in this country, and to the myriad sorts and sizes of forest zoological denizens, there are probably at least 25,000 species of flowering plants and ferns, besides a vast uncounted host of lesser vegetation, including mosses, algae, lichens, fungi, and bacteria.

As Clapp has pointed out in A National Program of Forest Research (published by the American Tree Association, 1926), the forest, while exceedingly complex, is a biological unit wherein all the component parts affect the whole, often vitally. It is not possible in this brief account to do more than hint at a few of the beneficial and detrimental effects of the subordinate forest vegetation on the forest itself. This complex forest society of living organisms produces numerous miscellaneous byproducts which, although of relatively minor importance in themselves, are yet in the aggregate of great actual and potential value to industry and society. Among those already established on a commercial basis are maple sugar and sirup, tanbark, sumac, cascara bark, wild nuts, blueberries and other wild fruits, and ornamental plants.

The maple sugar and sirup industry is chiefly confined to the optimum range of the sugar maple tree, which (aside from adjacent portions of Canada) embraces eastern New England, New York, Pennsylvania, the Lake States, the southern Appalachians, and a few other localities of the northern and northeastern States. Along the Pacific coast the bigleaf maple, and in various other places the silver maple, boxelders, and a few other species of maple are occasionally tapped. The sugar maple, with its varieties, is usually dominant and ordinarily comprises from 25 to 75 percent of the total stand of approximately 62,500,000 acres of the northern maple-beech-birch type in the United States in which the tree characteristically occurs.

The heaviest sap production, aside from the effect upon it of certain climatic factors, appears to be associated with great leaf production (large crown and numerous branches), together with good soil moisture and humus conditions, and a moderate amount of sunlight; in general, the maple sugar and sirup industry requires a different type of tree from the taller, clean-boled, few-branched, narrower-crowned type favored by the lumber trade. The maple sugar and sirup industry, with a product valued at several million dollars annually, is largely conducted on privately owned lands by individual farmers or associations of farmers. Because of present economic conditions current price quotations for "sugar-bush" lands hardly represent fair valuations. The George Washington (formerly Shenandoah) National Forest, Va., is issuing sugar maple tapping permits at 10 cents per tree per year. The latest census figures show for the 9 leading States, 34,823 farmers reporting, 1,341,491 pounds of maple sugar and 2,341,023 gallons of sirup produced during

1929, which was a relatively poor season. The industry is a leading one in parts of Vermont, New York, Ohio, and other States. It furnishes employment and a source of income in late winter or early spring, and has an important bearing on local phases of transportation, such as roadbuilding, as well as on the confectionery industry generally.

The American tanning trade utilizes an enormous amount of forest products, both domestic and imported. In 1925 (the latest year for which census figures are available) 158,942 tons of hemlock bark, 103,775 tons of oak bark, 104,268 tons of chestnut wood, and 1,139 tons of sumac extract from American forest lands were consumed in the tanning industry. This material is chiefly produced in the Eastern, Southeastern, and Pacific Coast States, although oak and sumac species are distributed (and potentially available) almost throughout the United States.

Native chestnut is the source of nearly one third of the vegetable tanning materials grown in this country, wood unsuitable for lumber purposes being chiefly employed for this purpose. The natural range of chestnut in the United States is from central New England, through Pennsylvania, Maryland, and northern Virginia, following the southern Appalachians (where it reaches its best development) into the northern parts of Georgia, Alabama, and Mississippi, and westward into central and eastern Tennessee and Kentucky, to Indiana and the more eastern portions of lower Michigan. Unfortunately the chestnut blight has already spread throughout the range of chestnut. In 1930 the Division of Forest Pathology of the Bureau of Plant Industry estimated that at least 80 percent of the chestnut trees as far south as Virginia were either dead or infected with blight, and the infection is still spreading. Thoroughly healthy stands are rare, perhaps nonexistent. Fortunately, however, the wood loses its tannin content very slowly, and trees dead 25 or 30 years are, so far as their wood is then sound, practically as good as living trees for use in the tanning industry. In spite of this devastating scourge, commercial stands of chestnut still occur, occupying perhaps about 15 million acres, composed of living (though mostly diseased), dying, and dead trees. Blight-killed trees remain usable for lumber for 5 or 6 years after death, and for an even longer period for other purposes, such as posts, pulpwood, fiber board, and tannic acid.

Large sums of money have been spent by the Federal Government, by the State of Pennsylvania, and by private individuals in Delaware, and energetic effort has been made by other public and private agencies to combat the chestnut-blight disease, without avail. Many authorities believe that the species, unless some unforeseen method of treatment or control soon appears or blight-resistant strains are shortly developed, is doomed to extinction, necessitating reliance on oak, pine, and other species eventually to supplant chestnut. Ashe (in 1912) estimated the yield of average 60-year-old stands of chestnut in Tennessee, based on a cut of trees of 10 inches in diameter and larger, as varying (according to site quality) from $32.70 to $66.80 per acre annually, with stumpage based at $1 a cord. Under such conditions and in the event that means were later forthcoming of stopping the blight or of developing immunity, chestnut growing on these cheap forest lands might be a very profitable undertaking.

Hemlock bark is the most important single item in American-produced tanning material and is especially profitable in connection with pulpwood and fiber-board production, for which latter purposes peeled logs are preferred. Since under present conditions the price of hemlock is decidedly low, the value of the species for tanning, in addition to its use for paper pulp and fiber board is of distinct advantage in lumbering operations. The eastern hemlock is confined (aside from southeastern Canada) to New England, the Middle Atlantic States, the Appalachian Mountains, Ohio, Michigan, and Wisconsin. Latest available estimates of its stand in the United States are about 12 billion board feet, the greater part of which is privately owned. The western hemlock, which occurs largely on Federal lands, ranges from Alaska to western Montana and northern California, the latest available estimates of its stand in the United States, exclusive of Alaska, being about 85 billion board feet. Its bark is somewhat richer in tannic acid per unit area than that of eastern hemlock but is only about half as thick, so that it is inferior to its eastern relative as a source of tanbark.

The bark of cascara buckthorn, a tree occurring from British Columbia and the southeastern borders of Alaska to western Montana and northern California, is an important item in *materia medica.* The tree is largely limited to areas along or near streams and to swales and moist slopes, and usually occurs in admixture with other species; probably more than half of the stand is privately owned. In general the bark is best handled as a forest byproduct, but the specific use of certain specially favorable lands for growing cascara, under private ownership, is a possibility worthy of future consideration. Nearly all of the commercial stand of cascara buckthorn is west of the Cascades, where it has been estimated that 75 percent of the region, or about 15 million acres, will produce bark in paying quantities. Full utilization of this resource would be ahead of present consumption but hardly in excess of possible future demand. In removing the bark care must be taken not to girdle the tree, injure the roots, remove more than about a quarter (or at most a third) of the bark, or to have the incised portions too close together. It has been estimated that the average section of 640 acres within the optimum belt of the species will, if properly managed, yield 0.7 ton of medicinal bark annually, worth, according to quality and the season price scale, $80 to $200. The cut of bark on six national forests of Washington-Oregon over a period of 13 years has amounted to about 316 tons valued at over $30,000. Vancouver is a chief port of shipment for cascara, an average of over 30 tons, valued at over $6,200, being exported therefrom annually. Munger (Journal of Forestry 17(5): 605–607. 1919) reports that in the Northwest cascara-bark collection is essentially a home industry for spring, when the bark peels readily, and that for many Coast Range settlers it is the chief source of ready cash during the first years of land clearing.

The forest lands of the United States produce an enormous wealth of edible nuts and seeds. For example, the pecan crop of the United States, according to the 1929 census figures, was derived from about 5½ million wild and cultivated trees of bearing age, which produced 26,150,546 pounds of nuts whose value, at the conservative retail figure of 20 cents a pound, was $5,230,109. Over half the bearing trees are wild, chiefly occurring on privately owned land; the cultivated trees, of course, produce the higher-priced grades of nuts. The piñon industry is confined to the Southwest, from western Texas to central Utah and southeastern California. The juniper-piñon type covers approximately 100 million acres, largely owned by the Federal Government. The harvest is uncertain because of the prolonged periods of drought to which the Southwest is subject, good seed years being attendant upon a proper amount of rainfall. In 1925, a good seed year, 1,200,000 pounds of shelled piñon nuts were shipped out of New Mexico alone, according to available Forest Service records. The gathering of piñon nuts is an important seasonal job for certain residents, especially the native Mexican and Indian population.

Edible wild fruits are another important byproduct of the forest. Wild blueberry picking, for example, is on a commercial basis in several regions of the country, notably New England, parts of the Middle Atlantic States, the Blue Ridge region of Virginia, and parts of Montana, Washington, and Oregon. Over 30 species of the blueberry genus, most of them widely distributed, occur on the forest lands of the country, more especially in the North and Northeast, the mountainous districts of the South, the Rocky Mountain region, and the Pacific Northwest. Five species of the related huckleberry genus are native in the wooded regions (mostly privately owned) of the Eastern States. Western species of blueberry occur chiefly on Federal, railroad, and State lands. Accurate figures as to the extent of the blueberry-huckleberry industry are lacking, but it furnishes seasonal employment to thousands of people, and many thousands of boxes of fruit are picked annually for table use and the canning trade.

Where it is abundant within its range, southwestern Oregon to central California, the Pacific plum is an important element in local economy; when its excellent fruit ripens in summer other local work is often suspended and it is one of the most important food plants among certain Indian tribes, especially the Klamath Indians.

Accurate figures are largely lacking for values involved in the forest ornamental plant industry. There are enormous numbers of ornamental plants in the wooded sections of the country, many of which now enter the horticultural trade; doubtless many more will ultimately do so. Rhododendrons, azaleas, mountain laurel, and other ericaceous plants are shipped out annually, by the carload, from the mountain forests of North Carolina and other southern States, and the total area of acid soils in the wooded districts of the East where these species occur is probably in excess of 15,000,000 acres, probably the larger part of which is privately owned. The latest figures available, which are for the calendar year 1931 and represent fairly average conditions, show that 17,110 leucothoe plants were removed for horticultural use, under permit at a nominal sum, from the Unaka National Forest, Tenn., while 37,547 other ornamental shrubs (chiefly rhododendron and mountain laurel), priced at $3,434.41, were sold under permit from three Appalachian national forests, the Pisgah, Monongahela, and Unaka. Removal of rhododendron and mountain laurel, where dense, assists in the establishment of timber reproduction, and clear-cutting or severe burning of timber in bottomlands tends to favor occupancy of such sites by rhododendron. On the other hand, removal of these species from the forest on a large commercial scale has in some cases resulted in local extermination of rhododendron and other ornamental shrubs of the heath family. Extermination (rather than thinning) of these species is objectionable, especially along and near highways, not only on account of their pecuniary value, but because they greatly enhance the beauty of the woods and when in bloom attract large numbers of visitors. In fact, for some mountain communities these shrubs are an important advertising asset, helping to bring in a seasonal tourist trade which is a vital source of local income.

The Christmas-tree industry is a very large one, the annual consumption in the United States being estimated at about 10,000,000 trees, which, at the very conservative retail figure of 50 cents per tree, would amount to at least $5,000,000 a year. No other country in the world has such a wealth of native conifers as the United States, and there are possibilities as yet undeveloped in the Christmas-tree trade both as a private business and from a public forest management standpoint. The Christmas-tree business, when properly conducted, involves a selective yearly thinning of the stand with a continuous annual supply as the objective. As conducted on the Pike National Forest in Colorado it largely represents a much-needed thinning of young Douglas fir stands, the reproduction of which ordinarily tends to be thicker than is desirable. The city of Denver, Colo., annually consumes about 40,000 Christmas trees plus 500 tons of boughs (for wreaths and other decorations) cut under permit from the Pike Forest, an operation involving a thinning of about 200 to 400 acres of forest annually. Prior to Forest Service management local Christmas-tree demand in Denver was largely met by promiscuous and destructive cutting on private lands, unsightly lopping of trees along mountain highways, and similar acts of vandalism. Such undesirable practices still largely obtain in many localities where forest management has not been brought to bear on the problem. It the East, one Pennsylvania farmer, on 1,500 acres of woodland, has annually averaged $5,400 net over a 7-year period from the sale of Christmas trees, handling his crop on a selective-cutting basis.

The pre-Christmas season makes a wide-spread demand for labor to cut and handle not only Christmas trees but a great diversity of evergreens for wreaths and other decorative purposes, nearly all of which are obtained from the forest: Conifers, lycopods, and club-mosses from nearly all parts of the country, mistletoe from the South and the South Central States, holly and kalmia in the Eastern States, toyon, Oregon-grape, and salal from the Pacific States, and so on. As mistletoe is a destructive parasite of timber species its harvesting for decorative purposes is a positive benefit to the forest and is worthy of encouragement. Unfortunately, however, only one of the two native mistletoe genera possesses ornamental values.

Coville (U.S.Dept.Agr. Farmers' Bul. 1693) reports that the coastal portions of Delaware and Maryland are the present center of production for American holly greens and that this center is definitely moving southward. He states that in Maryland, during 1930 and 1931, local retailers paid approximately 15, 25, and 55 cents apiece for 10-, 15-, and 24-inch wreaths, respectively, and that bulk holly, in standard-size boxes (2 by 2 by 4 feet) brought pickers about $2 per box. District Forester Seigworth, of the Maryland Department of Forestry, estimates that, on the average, 10,000 persons (including many entire families) in the eight counties on the Eastern Shore of Maryland engage yearly in harvesting holly, from which they obtain an annual income of $150,000. About 10,000 boxes are shipped annually. The Delaware Commission for the Conservation of Forests reported in 1927 that the holly-products industry of that State amounts to an average annual shipment of about 7,600 cases, valued at about $400,000 and consisting of 1,500,000 wreaths besides loose sprays and branches. The crop is harvested chiefly by local farmers who receive about $100,000 for their labor.

As already intimated, these miscellaneous forest byproducts have many valuable sociological relations. They furnish seasonal and local employment to numerous persons in the wooded portions of the country. The tapping and rendering of maple sap comes in late winter and early spring. Cascara peeling is largely a spring occupation. In North Carolina, especially in the region surrounding Marion, the collection of galax leaves furnishes employment to a great number of local people between November and March. Expert pickers, it is reported, gather about 10,000 leaves a day, for which they receive in the neighborhood of $5. The pre-Christmas season makes a country-wide demand for ornamental forest evergreens. All these sources of seasonal local employment bring in cash returns or obviate expenditures as in the case of individual fuel supply, foods, etc., and render possible not only the maintenance of better standards of living but also in many cases the actual existence of communities in forested areas and elsewhere which otherwise could not survive.

The forest produces a great variety and amount of food available for human consumption and, even at this date, numerous Indian tribes are largely dependent upon the forest for subsistence. This vegetable human food of the forest consists of a wealth of wild fruits, edible seeds and nuts, bulbs, tubers, and farinaceous roots, succulent stalks, "greens", mushrooms and other edible fungi, etc.

The future possibilities of miscellaneous forest byproducts are exceedingly diversified and are of great importance. For example, an immense potential source of rubber supply is on hand in numerous native plants, largely of the forest, such as rabbitbrushes, pingues, goldenrods, spurges, cichoriaceae, etc., although much research will doubtless be needed to make rubber commercially available therefrom. There is an immense variety of indigenous forest medicinal plants, some of which are already in commercial use. A vast host of ornamental herbs, shrubs, and trees adorn the American forests, and largely affect their aesthetic appeal; these are becoming of increasing importance in the American horticultural trade.

There are desirable fiber-producing plants such as yuccas and dogbanes; lacquer and gum-producing species such as acacias and sumacs; outstanding honey plants, in extraordinary variety and abundance and often widely distributed, some of which (as in parts of California and the Southwest) are mainstays of the local honey industry; matting and basketry plants; dye plants; upholstery-stuffing material such as mosses and tillandsias; and products with numerous other uses, including yucca wood for splints, amole and soapberry for soap, manzanita roots for pipe bowls, etc. Twenty-eight hundred pounds of moss (mostly sphagnum) was removed under permit during the calendar year 1931 from the White Mountain National Forest, N.H., and the Unaka National Forest, Tenn., chiefly for surgical dressings and horticultural packing.

No satisfactory inventory has yet been made of the extent and character of the minor products of American forests. For most of the species research is necessary to determine: (1) Their beneficial or detrimental relationship to the forest and to forest management, including timber, watershed, range, wild life, recreation, or other values; and (2) methods of utilization consistent with highest and perpetuated productivity and compatible with other outstanding forest uses and values.

Forests serve as natural laboratories for research. Their vegetation is proving to be an increasingly important source of supply for the plant breeder. Examples may be cited in the use of western forest species in the development of needed types of strawberry, of native aconite for the drug trade, of native forest grasses in the production of cultivated forage plants for range and pasture improvement at home and abroad, and in the breeding of plums. Important research is in progress on the role of the forest in harboring obnoxious plants, such as those that are poisonous, mechanically injurious, or which are abundant and worthless.

The proportion of forest plants known to be injurious to agriculture is relatively small; certain species serve as alternate hosts of timber and agricultural crop diseases, subjects which also require further study. For example, certain forest grasses serve as alternate hosts for cereal stripe rust, while barberries and buckthorns occupy similar roles for stem rust of spring wheat and crown rust of oats, respectively, and the thurberia bush harbors the cotton bollweevil. Further fields for study are indicated in the extent to which certain members of the forest cover shelter insects and other organisms injurious to man and beast, and the relationship borne to forest protection methods by various subsidiary plants, e.g., resinous shrubs such as snowbrush and bearmat, the inflammable spores of certain clubmosses, and certain fibrous tree lichens of the alectoria-evernia type. In the maple sugar sirup industry more information is needed as to the best number of tappable trees per acre, methods of obtaining the proper number per unit area of trees of the most desired "sugar orchard" type, the best diameter and depth of taphole, and, in general, methods and periods of tapping that will insure maximum continuous yield. Research is also needed regarding methods of collection, cutting, etc., of medicinal and ornamental plants conducive to permanent yield, and as to the use of bee-plant range at heights of flowering seasons of the most important plants.

The forest economics aspects of these minor by products need additional emphasis for, by their proper utilization, opportunity is afforded here and there to supplement income from forest properties to a greater or less extent.

Regulations needed for minor forest by products on Federal lands cover permits for sales and collection methods based upon use in conformity with the best management principles, and in recognition of the principle that the objective sought is permanent utilization and enjoyment of these byproducts, as opposed on the one hand to nonuse and on the other to abuse, destruction, or other uneconomic management. However, further research is necessary to furnish the fundamental information on which the best management principles for these minor forest byproducts must be based. Maryland, California, and a few other States have enacted (largely on the initiative of the Wild Flower Preservation Society and other conservation agencies) laws and regulations to protect and perpetuate outstanding ornamental species of the forest, such as dogwood, trailing-arbutus, kalmia, orchids, toyon, etc. Additional legislation of this sort is doubtless desirable for other species and in other places to prevent extermination or decimation of aesthetic, rare, or otherwise valuable or interesting forest plants. Some communities and States have laws and regulations for eradication or control of obnoxious agricultural and highway plants, such as ragweed and puncturevine, and there is probably a field for similar legislation in certain localities with respect to obnoxious forest species.

PROGRESS IN FORESTRY AND EXISTING PLANS

One of the essentials for the formulation of a comprehensive forest policy and plan of land use is an understanding of the wide variation, as between different aspects and as between different classes of land ownership, in the present practice of forestry and the formulation of plans for future progress.

In the following pages are presented the basic purposes, the progress, and accomplishments, from the standpoint of forestry practices, first, of Federal administrative agencies responsible for the national forests, the Indian forests, the national parks and monuments, and other Federal forest land. These are followed by a review of research in forestry. The treatment of the Forest Service includes particular reference to underlying objectives, and the principles which have been followed in striving to meet these objectives.

A group of two sections reviews the situation as to State, county, and municipal ownership and management of forest lands, including the historical setting, the divergence of State forest policies, the objectives, and the progress attained.

The last five sections review certain outstanding phases of the forestry situation that have to do particularly with private ownership or enterprise. The first of these discusses the character, extent, and causes of forest devastation and deterioration—ills which tie in very closely with private ownership of forest land. The succeeding discussion of the break-down of private forest-land ownership deals with the extent and causes of the recent unprecedented shifts from private to public ownership largely via tax delinquency. The section on status and opportunity of private forestry reviews the status of outstanding economic problems as they affect the private handling of forest land, and some of the equally important economic problems involved in private forest-land management, and compares the existing status and financial results of private forestry with the potentialities. Following a review of forest research on the part of endowed and other private agencies, a final section summarizes the considerable degree of public regulation of privately owned forests which now exists and the principles upon which this regulation is based, and presents some of the factors to be taken into account in considering an expansion of public regulation.

THE NATIONAL FORESTS

By C. M. **Granger**, Director, Forest Survey

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THE CREATION AND THE CONTRIBUTION OF THE NATIONAL FORESTS

In 1891, the people of the United States said to themselves something like this:

> We have been parceling out the public timberlands right and left for, lo! these many years; we have believed that the quickest and best way to build up this country was to get all the publicly owned natural resources into private hands as quickly as possible; the results have been mixed. On the one hand, we have seen private initiative in the forests furnish the lumber that built the farm houses and the towns in the great Mississippi Valley; the timberland bonuses we gave to railroad builders helped us to get some of our transcontinental railroads; many cleared acres have gone under the plow. But, on the other hand, there has been too much on the wrong side of the ledger; we have seen the lumbermen cut out and get out of New York and Pennsylvania, move into Michigan, Wisconsin, and Minnesota and go most of the way through the same process there; the experience promises to be repeated in the South, and it is only a matter of time until the same things happen in the great western forests. We don't like these deserted towns that remain in the wake of the sawmill, these vast areas of stumps. Where are we going to get our timber in the future if nobody takes an interest in where the next crop is coming from? We have hardly any public timberlands left in the East, in the Lake States, in the South, but we still have some in the West; we shall keep some of them, set up our own forestry enterprise, and see if we cannot do a better job of insuring the satisfaction of our present and our future needs for timber and for watershed protection.

So began the national forests—the symbol of a belated recognition of the economic error committed by the Nation in passing so much of its forest area to private ownership and of the intent of the people to better safeguard their forest welfare by direct action.

At first the national forests, then called forest reserves, were just just what the latter name implies—reserves. Then in 1897 Congress provided authority to administer them, to sell their timber, and granted broad powers to direct the utilization of their resources. In recognition of the large and intricate problem of technical land and organic resource management which their administration involved, the forest reserves were placed under the jurisdiction of the Department of Agriculture in 1905. In 1907 the name was changed to national forests as being more descriptive of their real character.

With the undertaking of systematic management in 1905 came the crystallization of the basic concept of the national forests. This concept was a unit of land containing a variety of resources, all with a public value, whose greatest potentiality for public service lay in a system of management which would so correlate the development and use of all the resources as to result in the largest net public benefit. Coordinate with this theory of management of the national forests was that of combining the maximum service to the Nation at large with the greatest possible benefit to the local population, to the extent of the latter's dependence on the national-forest resources. The controlling principle was stated to be the greatest good to the most people in the long run. This concept has activated and controlled the policies and practices on these Federal forests since that time.

What has been the result of this venture—a venture which at its inception was new in the United States but which had been of proven necessity in Europe's long forestry experience?

At first there was much local opposition to the national forests on the ground of so-called interference with the hitherto unrestricted use of the public domain. Bitter fights were waged in several parts of the West to defeat the enterprise and to do away with many of the national forests. By selecting the forest rangers and most of the forest supervisors from the local population, by locating the directive administrative organization mainly in the West, close to the forests and the users, by striving to reduce to a minimum the mistakes inevitable in the administration of a new project, and by adhering to the principle of making the national forests serve the local needs the program of regulated use gradually demonstrated its value to both the general public and the local user.

The annual payment of 25 percent of the national forest gross receipts to the counties in which the national forests lie, to be spent for schools and roads, and the expenditures by the Federal Government for roads in and adjacent to the national forests, have contributed heavily toward the favorable regard toward Uncle Sam as a local landowner. Opposition changed to strong support. Instead of seeking the abandonment of the enterprise, the demand became widespread for an expansion of the system. A score of eastern States have, by legislative enactment, expressed a desire to have the Federal Government establish national forests within their borders under the purchase provisions of the Weeks law. The cut-over private land problem has made the national-forest acquisition program welcome in the Lake States, and bids fair to invite substantial expansion of the national forests in several of the western States. Several private owners have recently offered to give their cut-over areas to the Federal Government to be added to the national forests.

So the national forests have been steadily built up until they contain between one seventh and one sixth of the commercial forest land in the United States. They embrace extensive and important watersheds. They include a third of the volume of the Nation's remaining saw timber and one eighth of its cordwood-size timber. There is evidence that by demonstration the national forests have exerted a measurable influence beyond their own borders toward the attainment by the Nation of the objectives sought in their own creation—

> securing favorable conditions of waterflows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States.

Though still facing many unsolved problems of protection and administration, and needing more facilities for their full development, present public support of the national forests proves that they have demonstrated the soundness of both the principle of conservation through wise use, and the policy of coordinated use of all resources to produce the largest net benefit. The public support is not only for continuing this form of Federal participation in the permanent management of the forest resources of the United States, but also for the further extension of the national-forest system, especially to the regions, mainly eastern, where Federal forest ownership is now far below its portion of the public share in the Nation's forestry enterprise.

What are some of the tangible things which furnish a sort of measure of the contribution which the national forests have so far made to the whole forestry development in the United States? For one thing, the nearly one sixth of the Nation's commercial forest land which is in the national forests is assured of permanent technical management under the plan of coordinated use of the various resources. Whereas, for the country as a whole, private timber is being cut at a much faster rate than it is estimated to be growing, the cut of national-forest timber is with rare exceptions fixed at or less than the estimated growth capacity of each cutting unit, and it is estimated that the total cut could be expanded nearly fivefold without exceeding the total sustained yield capacity of the national forests. The watersheds from which flow streams providing the domestic water supply of 6 million people, and the water for over a billion dollars worth of irrigation and power developments, are assured of management designed to preserve the watershed values. The regulated use of national-forest ranges has added materially to the stability of 25 percent of the range livestock industry in the West. The recreational grounds of over 32 million people, measured by 1931 use, are under management aimed at perpetuating and developing the recreational resources.

Seventy-five percent of the range used by big game animals in the 11 Western States is being given increasingly productive management, and the game is steadily increasing. And fire protection on the national forests has reduced the burned area so that for the 5-year period ending in 1930 it was only 7 percent over the objective, while on lands outside the national forests it was, for the same period, 11 times the objective.

In the Rocky Mountain and Pacific Coast States, where 53 percent of the commercial forest area and 42 percent of the saw-timber volume is in the national forests, these Federal properties play an important part in the forest economy of the region. Though the timber cut on the national forests in this territory as a whole is still only a fraction of the total cut of the region, established lumbering operations are coming more and more to depend partly or entirely on the national forests as the private timber is cut out. Since the cut of national-forest timber is limited to the growth capacity of the area, there is an ever-increasing leaven of permanence added to the timber industry as a portion of it moves steadily into the national forests.

The influence of this leaven goes beyond the direct contribution of the national-forest timber. The obvious economic and social advantages of stabilized forest industries and communities are becoming more apparent to the local population and local public agencies, and public measures in such matters as cooperation in forest-fire protection and improved methods of forest taxation are more widely favored and adopted as a means of encouraging permanent forest management on private forest lands. Timber owners themselves are gradually becoming more interested in managing their lands under sustained yield, both independently and in cooperation with adjacent national-forest timber.

Because the national forests contain one third of the saw timber in the United States, including a third of the Nation's last large remaining supply on the Pacific Coast, the regulated cut of national-forest timber will have a noticeable effect in lessening the gap between the cutting out of the remaining virgin supply of private saw timber and the coming into merchantability of the great areas of young growth on cut-over areas.

The substantial Federal ownership of timber on the Pacific Coast and in the northern Rocky Mountains has had a very real and very great value in preventing a still greater overburden of mature timber in private hands in these regions. This overburden is one of the major causes of the disastrous overproduction of forest products in the Pacific Northwest, with its bad economic and social consequences. Both the general and local economic welfare would be much better served if the national forests had been created before so much of the timber was privately acquired.

In the eastern half of the United States the national forests contain less than 2 percent of the commercial forest area and the saw-timber volume. Here their value so far is one chiefly of demonstration of the advantages of permanently managed forest properties. In the South, especially, where lies 40 percent of the Nation's forest land, nearly all privately owned and in the main potentially very productive, and where forest-fire protection and forest management are less advanced than in any other region, the demonstration forest and leadership possibilities of the little national-forest nuclei are very great.

These values as stabilizers and demonstrators relate not only to the timber of the national forests as a commodity; they concern also the watershed values, the forage resources of the western national forests, and the less tangible but highly important scenic, recreational, and educational values in the national forests. As each resource is discussed this will be brought out in greater detail.

Despite many acknowledged imperfections in the past and current execution of the national-forest project, and despite the fact that many problems remain for future solution, the foregoing is believed to be a fair appraisal of typical contributions by the national-forest enterprise to the attainment of the whole of the Nation's forestry objective. It is believed that it may be safely forecast that as further experience continues to improve the management, and as the undertaking expands in area, the contribution will be increasingly greater.

HOW THE PROPERTY WAS BUILT UP

The major part of the national-forest area has been made up from the unreserved public domain—in most cases what was left after private ownership had, over many years, acquired the choicer timberland under the public land laws. Thus, for the most part, the public land available since 1891 when the first national forest was created has lain in the mountainous portions of the West. Even here private ownership had acquired considerable areas within what were later established as the exterior boundaries of the national forests, both through selection of the better stands of timber and by the checkerboard land grants made by the Federal Government to aid the building of several of the transcontinental railroads. In addition to this form of alienation, there are within the national-forest boundaries private lands obtained under the mining and town site laws, and agricultural homesteads in the narrow valleys running up into the national forests or pocketed in the surrounding timbered areas. Thus, while there are 186,215,256 acres of land within the national-forest boundaries (table 1), 24,854,565 are in other than Federal ownership, leaving 161,360,691 acres of federally owned national-forest lands. Figure 1 shows the location of the national forests and of 3 purchase areas in Wisconsin and 1 in Mississippi which are are verging on national-forest status.

Table 1.—*National-forest areas and established purchase areas not yet proclaimed as national forests, by administrative regions (as of June 30, 1932)*

NATIONAL FORESTS

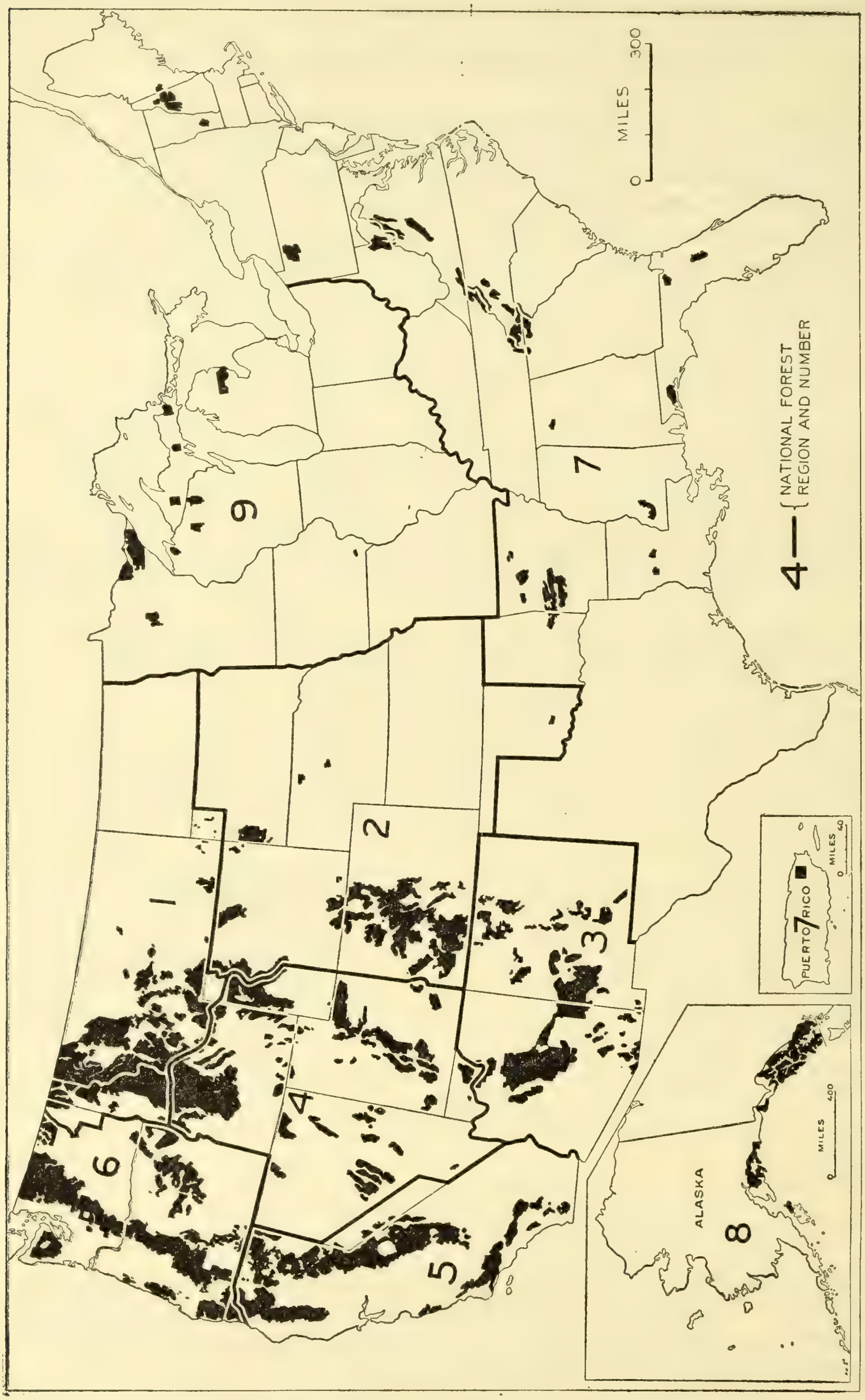
Region		Gross area	Alienated lands	Net area
No.	Name			
		Acres	*Acres*	*Acres*
1	Northern	26, 541, 106	3, 889, 020	22, 652, 086
2	Rocky Mountain	20, 926, 780	1, 764, 680	19, 162, 100
3	Southwestern	21, 277, 637	2, 129, 774	19, 147, 863
4	Intermountain	31, 099, 926	1, 350, 087	29, 749, 839
5	California	24, 220, 331	4, 861, 655	19, 358, 676
6	North Pacific	26, 946, 305	3, 855, 452	23, 090, 853
7	Eastern	10, 476, 844	5, 373, 998	5, 102, 846
8	Alaska	21, 397, 006	52, 724	21, 344, 282
9	Lake States	3, 329, 321	1, 577, 175	1, 752, 146
	United States	186, 215, 256	24, 854, 565	161, 360, 691

PURCHASE AREAS[1]

7	Eastern	325, 000	259, 970	65, 030
9	Lake States	477, 495	242, 001	235, 494

[1] Includes only those within which lands are being acquired.

Despite the fact that the Federal Government waited for "second table" for its forest-land meal, the public did get a large area of good grade forest land in the national forests. The public also got much of its land located where experience both in Europe and this country shows it should be—at the headwaters of streams. The protection, by ownership or strict regulation, of forests having a high watershed value has been generally recognized as an essential public function.


MILES
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4—{NATIONAL FOREST REGION AND NUMBER
1
2
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4
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6
7
8
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ALASKA
MILES
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400
PUERTO RICO
MILES
0
40

FIGURE 1.—National forest areas by national forest regions (as of June 30, 1932). The map shows strikingly the disproportionately small national forest acreage in the East where the slow growth by purchase has lagged far behind the development, chiefly from the public domain, in the West.

Though Congress in 1907 took away from the President authority, without specific congressional approval, to create new national forests, or to add to those existing, in six of the Western States, and later in three others, many individual additions have been made by Congress from the public domain upon the demand of local residents convinced of the benefits of nearby national-forest administration. This has been one of the most striking proofs of the success of the national-forest enterprise. Often this demand has involved lands with little or no timber on them, but of great local value for grazing or watershed protection.

In the Weeks' Law (act of Mar. 1, 1911), a new national policy was established—the purchase by the Federal Government of forest lands necessary to the protection of the flow of navigable streams. The Clarke-McNary Act of 1924 extended this policy to lands within the watersheds of navigable streams necessary for the production of timber. Under these acts the national forests east of the Mississippi River have been established, except those created chiefly from the public domain in Michigan, Minnesota, and Florida.

It became apparent early in the life of the national forests, both to the Forest Service and to local residents and forest users, that the national forests could much better serve their purposes nationally and locally if much of the privately owned forest land within the forest boundaries could be made a part of the national forests. Management of the national forests is complicated in many ways by the interspersed private timberlands, whose ownership is usually concerned only with liquidating their timber assets rather than with their permanent management for forest growing. Through local public support, and often upon local initiative, Congress passed a large number of acts authorizing the Forest Service to acquire privately owned lands within specifically described areas by the exchange therefor of an equal value in either national forest land or timber. Finally this plan so thoroughly demonstrated its soundness and value that in 1922 Congress passed the general exchange law authorizing this practice on all national forests. This act applies to lands within the exterior boundaries of the national forests, but so great has been the local interest in extending national-forest management to adjacent lands that a number of special bills have been passed extending the exchange authority to lands within specified limits outside the national-forest boundaries. Altogether under the exchange laws 1,205,100 acres have been acquired up to December 31, 1931. This has been mainly cut-over lands, though in some cases land bearing merchantable timber has been offered at such favorable rates as to justify its acquisition. Since the exchanges have usually been in the form of national-forest timber for private land and timber, the national forests have gained 814,685 acres in area by the exchanges.

FURTHER ADDITIONS FROM THE PUBLIC DOMAIN AND BY EXCHANGE

There is still a large area of public domain in the Western States, not now under any form of management, which by character and adjacency should be considered for addition to the present national forests or for the creation of new units. Figure 2 indicates the addition to the national forests and the new units proposed by the Forest Service to the President Hoover's Committee on the Conservation and Administration of the Public Domain, based on the existence of public domain suitable for national-forest purposes, and needing the national-forest type of management to develop its fullest usefulness. Within the exterior boundaries of the additions as proposed there are 34,523,592 acres. Of this, 19,017,210 acres are unreserved public lands, 1,901,344 acres are State lands, and 13,605,038 acres are private lands. This distribution of ownership is similar to that now existing within present national-forest boundaries. If these additions are made, the land-exchange practice now in effect on the national forests can then be extended to these areas. Perhaps 5 million acres or more of the privately owned lands would be suitable for acquisition by exchange. These additions to the national forests would serve to make the existing units even more useful by more nearly approaching the logical boundaries as fixed by natural conditions. A complete discussion of the public domain forest lands is contained in the section of this report dealing with "Public Doman and Other Federal Forest Land."

Almost entirely in addition to the areas indicated on figure 2, there are privately owned lands, extensive in the aggregate, adjacent to the western national forests which are logical parts of geographic and management units lying chiefly within existing national forests. The major part of such areas adjoins the national forests in Oregon, Washington, and Idaho. As these lands are cut over, or in some cases before, they should be acquired as national-forest lands by an extension of the national-forest exchange act. Since the exact limits to which such extensions of the national-forest boundaries should go are dependent in part upon constantly changing conditions as to ownership of the private land adjacent to the national forests, and the intent of ownership as to management of the lands, it is not possible to establish an exact figure for the area of this class of lands. Probably between 5 and 10 million acres would be included in this category for ultimate acquisition. Wherever feasible, extension of the national-forest boundaries should aim at including the whole of natural units, such as entire main slopes or watersheds. Usually the best management can be given where such natural units are under single control.

Inside existing western national-forest boundaries there are probably from 10 to 12 million acres of private land which should be given a national-forest status by exchange, or otherwise.

Much consideration by the local residents is being given to the possibilities of adding to the national forests the parts of the Oregon and California revested grant lands in Oregon which are within or adjacent thereto, under some plan which will liquidate the State and county equities in the O. & C. lands established by the revestment act of June 9, 1916.

The rate at which it has been possible to accomplish land exchanges so far forecasts a long period before even the land inside present forest boundaries which should be acquired can be obtained in this way. Only a minor portion of the timber cut on national-forest sales can be used in effecting exchanges because the use of such timber for this purpose reduces the cash payment to the counties involved from the 25 percent of national-forest gross receipts which is paid each year to the counties in which the national forests are located. Since such exchanges, by adding to the productive capacity of the national forests, inure to the benefit of the counties in the long run, county authorities generally have favored the exchange practice, but in most cases have felt able to relinquish only part of the 25 percent fund revenue for this purpose. The extremely conservative timber-sale policy on the national forests restricts the revenue from this source. Hence many exchange possibilities of a most favorable nature in the public interest have to be passed by for lack of means wherewith to take advantage of them.

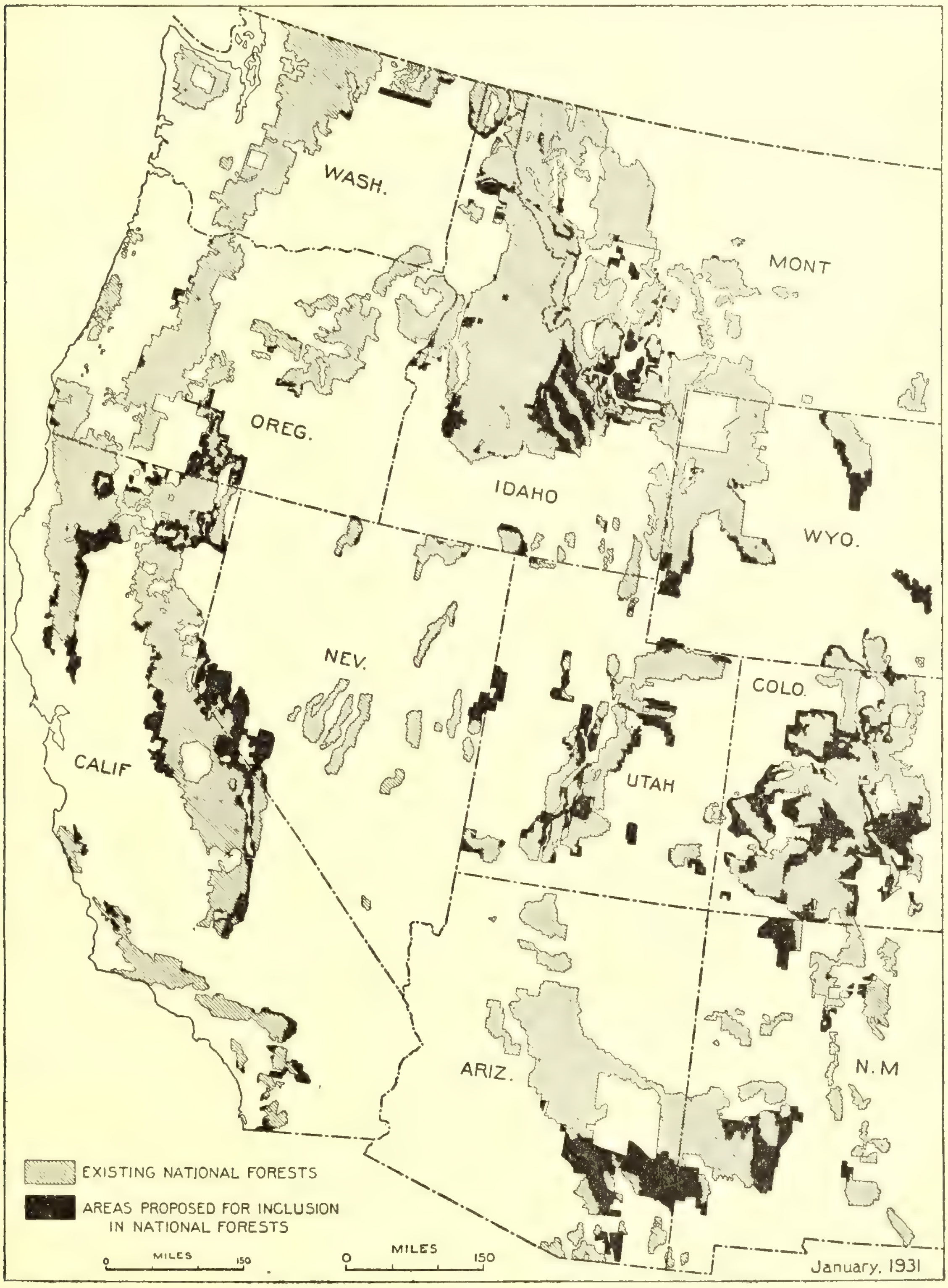
WASH.
MONT
OREG.
IDAHO
WYO.
NEV.
CALIF
UTAH
COLO.
ARIZ.
N.M
EXISTING NATIONAL FORESTS
AREAS PROPOSED FOR INCLUSION IN NATIONAL FORESTS
0 MILES 150
0 MILES 150
January, 1931

FIGURE 2.—Areas involving public domain proposed by Forest Service as additions to existing national forests or for establishment of new national forests would result in more closely approximating the logical boundaries as determined by natural conditions.

One means of accelerating the progress of exchanges lies in authorizing the use of the unreserved public domain as trading stock for national-forest exchanges. There are opportunities in the public interest to acquire private land within national-forest boundaries if public domain land could be traded for it. Legislative action to this end would be desirable.

THE ACQUISITION PROGRAM

With the approval of the National Forest Reservation Commission, the Secretary of Agriculture has set up a program of 41 purchase units under the purchase policy established by the Weeks law and enlarged by the Clarke-McNary law. Of the total area proposed for Federal management under this program—between 14 and 15 million acres—almost exactly half is now under Federal control; 2,503,875 acres having been reserved from the public domain, transferred from other forms of reservation, or acquired by exchange, and 4,727,680 acres obtained by purchase at an average cost of $4.48 per acre. The remaining half has been estimated to cost about $4.05 per acre, but the current decline in land values probably forecasts a somewhat lower price. Table 2 shows in detail the status of the program as of June 30, 1932.

TABLE 2.—*Federal acquisition program, accomplished and proposed*

(A) PRIMARILY FOR WATERSHED PROTECTION

Region and State	Accomplished up to June 30, 1932									Required to complete existing units					
	Units established[1]	Gross area	Area federally managed	Ratio, federally controlled to total forest area of State	Area purchased or in process of purchase	Ratio, purchased to total acquired	Average cost per acre	Total cost of purchase and relation to total expenditure		Additional area to be acquired[2]	Total then under Federal management	Ratio, federally managed to total forest in State	Average cost per acre	Total cost of purchase and relation to total expenditure	
NEW ENGLAND	*Number*	*Acres*	*Acres*	*Percent*	*Acres*	*Percent*	*Dollars*	*Dollars*	*Percent*	*Acres*	*Acres*	*Percent*	*Dollars*	*Dollars*	*Percent*
Maine	1	53, 300	33, 781	0. 23	33, 781	0. 71	5. 74	193, 792. 06	0. 91	[2] 19, 019	52, 800	0. 36	5. 75	109, 359. 25	0. 35
New Hampshire	1	801, 900	500, 955	11. 13	500, 955	10. 60	8. 68	4, 348, 270. 27	20. 51	276, 245	777, 200	17. 26	6. 00	1, 657, 470. 00	11. 60
Vermont	1	102, 100	31, 491	. 96	31, 491	. 67	11. 01	346, 672. 00	1. 64	268, 509	300, 000	9. 14	8. 50	2, 282, 326. 50	5. 08
Regional total	2	957, 300	566, 227	2. 54	566, 227	11. 98	8. 63	4, 888, 734. 33	23. 06	563, 773	1, 130, 000	5. 07	7. 18	4, 049, 155. 75	17. 27
APPALACHIAN															
Alabama	1	198, 425	134, 535	. 62	116, 826	2. 47	4. 86	567, 597. 79	2. 68	20, 550	155, 085	. 72	5. 00	102, 750. 00	1. 30
Georgia	3	660, 600	341, 797	1. 48	341, 783	7. 23	5. 37	1, 836, 683. 20	8. 66	266, 013	607, 810	2. 64	4. 65	1, 237, 692. 75	5. 94
Kentucky	1	580, 000	----------	-------	----------	-------	-------	----------------	-------	509, 000	509, 000	4. 83	5. 00	2, 545, 000. 00	4. 92
North Carolina	8	1, 338, 500	451, 160	2. 14	439, 721	9. 30	5. 79	2, 545, 007. 49	12. 00	800, 854	1, 252, 014	5. 94	4. 30	3, 440, 853. 50	11. 56
Pennsylvania	1	726, 340	371, 201	2. 81	371, 181	7. 85	4. 79	1, 778, 725. 28	8. 39	234, 999	606, 200	4. 59	6. 00	1, 409, 994. 00	6. 16
South Carolina	1	244, 300	48, 950	. 39	48, 950	1. 03	5. 88	287, 755. 66	1. 36	188, 170	237, 120	1. 88	4. 00	752, 680. 00	2. 01
Tennessee	3	865, 100	393, 672	2. 76	393, 668	8. 33	4. 82	1, 897, 925. 57	8. 95	394, 896	788, 568	5. 54	4. 49	1, 773, 082. 25	7. 09
Virginia	4	1, 244, 500	619, 825	4. 10	619, 690	13. 11	3. 67	2, 272, 324. 88	10. 72	490, 244	1, 110, 069	7. 34	4. 22	2, 067, 160. 00	7. 61
West Virginia	2	819, 100	336, 102	3. 38	336, 102	7. 11	3. 43	1, 152, 103. 36	5. 43	376, 155	712, 257	7. 15	3. 91	1, 469, 129. 50	5. 06
Regional total	14	6, 676, 865	2, 697, 242	1. 91	2, 667, 921	56. 43	4. 62	12, 338, 123. 23	58. 19	3, 280, 881	5, 978, 123	4. 23	4. 51	14, 798, 342. 00	51. 65
OZARKS															
Arkansas	2	2, 221, 522	1, 288, 920	5. 82	342, 841	7. 25	3. 44	1, 177, 665. 07	5. 55	765, 652	2, 054, 572	9. 28	4. 06	3, 105, 663. 50	8. 27
Oklahoma	2	344, 249	61, 489	. 52	61, 489	1. 30	1. 46	89, 663. 07	. 42	297, 000	358, 489	3. 03	2. 50	742, 500. 00	1. 61
Regional total	3	2, 565, 771	1, 350, 409	2. 62	404, 330	8. 55	3. 13	1, 267, 328. 14	5. 97	1, 062, 652	2, 413, 061	4. 68	3. 62	3, 848, 163. 50	9. 88

[1] Where single units are in 2 or more States they are counted in each State, but regional totals show the correct number in each region.

[2] This column includes proposed extensions of existing units as follows: Green Mountains, 198,000 acres; Mount Mitchell, 2,000 acres; Unaka, 52,000 acres; French Broad, 111,300 acres; Monongahela, 153,800 acres; Kiamichi, 26,000 acres; Hiawatha, 118,000 acres; Huron, 1,000 acres; and Ottawa, 90,000 acres.

TABLE 2.—*Federal acquisition program, accomplished and proposed*—Continued

Region and State	Accomplished up to June 30, 1932									Required to complete existing units					
	Units established	Gross area	Area federally managed	Ratio, federally controlled to total forest area of State	Area purchased or in process of purchase	Ratio, purchased to total acquired	Average cost per acre	Total cost of purchase and relation to total expenditure		Additional area to be acquired	Total then under Federal management	Ratio, federally managed to total forest in State	Average cost per acre	Total cost of purchase and relation to total expenditure	
	Number	*Acres*	*Acres*	*Percent*	*Acres*	*Percent*	*Dollars*	*Dollars*	*Percent*	*Acres*	*Acres*	*Percent*	*Dollars*	*Dollars*	*Percent*
GULF AND SOUTHEAST															
Louisiana	1	105,567	24,575	.13	24,575	.52	3.18	78,217.78	.37	68,992	93,567	.49	3.65	251,820.80	.64
Mississippi	1	325,000	65,030	.35	65,030	1.38	4.00	260,264.14	1.23	194,970	260,000	1.40	5.00	974,850.00	2.38
Regional total	2	430,567	89,605	.15	89,605	1.90	3.78	338,481.94	1.60	263,962	353,567	.60	4.65	1,226,670.80	3.02
Puerto Rico		65,950	13,824	3.07							13,824	3.07			
Total watershed units	21	10,696,453	4,717,307	1.86	3,728,083	78.86	5.05	18,832,667.64	88.82	5,171,268	9,888,575	3.90	4.63	23,922,332.05	81.82
(B) PRIMARILY TO STIMULATE PRODUCTION OF TIMBER															
GULF AND SOUTHEAST															
Florida	3	792,842	584,795	2.48	236,229	5.00	3.95	931,967.73	4.40	138,331	723,126	3.06	3.53	488,688.50	2.74
Louisiana	3	315,572	61,275	.32	61,275	1.29	4.02	246,044.62	1.16	222,700	283,975	1.49	3.00	667,355.00	1.77
South Carolina	2	175,000								175,000	175,000	1.38	6.00	1,050,000.00	2.03
Regional total	8	1,283,414	646,070	.46	297,504	6.29	3.96	1,178,012.35	5.56	536,031	1,182,101	.85	4.12	2,206,043.50	6.54
LAKE STATES															
Michigan	4	1,401,407	687,009	3.35	335,404	7.09	1.73	581,450.07	2.74	795,411	1,482,420	7.23	2.50	1,988,527.00	4.96
Minnesota	2	1,884,610	943,969	4.31	131,555	2.79	1.79	234,856.58	1.11	408,199	1,352,168	6.17	2.50	1,020,497.00	2.43
Wisconsin	6	1,257,974	237,200	1.36	235,134	4.97	1.60	376,035.29	1.77	728,833	966,033	5.55	2.50	1,822,080.00	4.25
Regional total	12	4,543,991	1,868,178	3.12	702,093	14.85	1.70	1,192,341.94	5.62	1,932,443	3,800,621	6.36	2.50	4,831,104.00	11.64
Total timber units	20	5,827,405	2,514,248	1.26	999,597	21.14	2.37	2,370,354.29	11.18	2,468,474	4,982,722	2.50	2.85	7,037,147.50	18.18
Grand total	41	16,523,858	7,231,555	2.15	4,727,680	100.00	4.48	21,203,021.93	100.00	7,639,742	14,871,297	4.42	4.05	30,959,479.55	100.00

Although the act of June 2, 1930, authorizes an appropriation of $3,000,000 for acquisition for the fiscal year 1933, the actual appropriation was reduced to $200,000 as a part of the economy program. This sum is barely enough to complete unfinished business and permit the retention of part of the highly specialized and skilled year-long organization pending resumption of purchases. As soon as the Government's financial situation permits, purchase funds should be restored at the annual rate of not less than $3,000,000.

When the present specific purchase program is completed, the total Federal forest holdings in the States concerned will be only 4.42 percent of all the forest land in these States. There are many indications that the Federal participation in forest-land ownership should be materially expanded, particularly in the eastern part of the United States. Of late proposals have been made that the purchase of lands bearing mature timber should be undertaken on a large scale as one means of decelerating the overliquidation of private stumpage, with its adverse effects on both the national timber supply and regional economic situations. The possible ultimate extent and character of Federal ownership is discussed in the section, "The Probable Future Distribution of Forest-land Ownership."

There is every indication that Federal ownership of forest lands will be substantially increased by gift from private owners. The Clarke-McNary Act provides for acceptance by the Federal Government of lands donated for national-forest purposes, with reservation by the owner of timber-cutting rights for a reasonable period if he so desires. One such gift involving 100,000 acres, mostly cut-over, in Idaho has just been accepted; another of a smaller tract in California. Much more of this form of acquisition is expected to follow in the near future as a part of the breakdown of private forest-land ownership.

MANAGEMENT AND USE OF THE RESOURCES OF THE NATIONAL FORESTS

THE PRINCIPLE AND PRACTICE OF CORRELATED USE UNDER UNIFIED CONTROL

The central thought in the management and use of the resources of the national forests is to so adjust one use to the other that the greatest net public benefit will result—to obtain the greatest total of crops, uses, and services. Where necessary the attainable maximum of any one of these can be relinquished if the grand total of public values is thereby increased. Where one use must be exclusive, the highest use in the public interest is given the right of way. Where two or more uses can occupy a given area with some concession by each, a suitable compromise is effected. Thus, in the first case, where recreational use would incur risk of pollution of a city water supply, it is excluded from the watershed; where public use would create an unacceptable risk on an area of unusual fire hazard on which a new tree crop is being fostered, the public is excluded during the fire season; where a water-power development would destroy or seriously impair the recreational or æsthetic value of a lake, it is excluded if the latter values are held to be paramount in the public interest. In the second case, timber cutting is usually permitted on watersheds, but so regulated as to avoid impairment of the watershed value; timber growing and livestock grazing may use the same area as long as the latter use does not prevent or unduly damage forest reproduction; and selective timber cutting may proceed with scarcely any interruption of the nonconcentrated forms of recreational use of the woods. Almost every national forest furnishes an example of a large variety of overlapping uses so harmonized as to avoid any measurable conflict—timber-sale cutting, livestock grazing, water supply for domestic, irrigation, and power purposes, recreation, game conservation, and many others. Timber-management plans specify particular measures where required to safeguard lakeside or roadside beauty, to avoid watershed damage, and to exclude livestock for a temporary period after cutting if necessary to allow natural restocking of forest growth to become established. Range-management plans provide for keeping stock away from tourist camp grounds or springs used by campers or out of areas needed exclusively for game. Plans for recreational units provide for the particular type of recreation best suited to the area, so that a lone cottage will not occupy a place needed for a public camp ground or a resort development. And so on.

In order to attain this objective of correlated use it has been necessary to adhere rigidly to the original concept of a national forest and of the form of organization essential to its most productive management. It is important to understand the true nature of the national-forest enterprise as established by over a quarter century of laws, appropriations, judicial and administrative decisions, established policies and practices.

This original concept of a national forest was a unit of land to be managed by a single agency for the production of commodities (timber, forage, etc.), services (watershed protection, etc.), and uses (recreation, game, etc.), which are inherent in the land and possessed of a public value. Unity of purpose in management and undivided control and responsibility were and are indispensable factors in the concept and in its execution.

At the very beginning of national-forest administration it became evident that in order to obtain a high level of technical land and resource management, the Forest Service would have to utilize a wide range of technical and expert personnel of various kinds. Accordingly it brought in as full-fledged members of the Service the technicians needed for the actual execution of the task itself, and for the research work which could best be done as a direct part of the enterprise. Thus foresters, logging engineers, range-management experts, surveyors, road and hydroelectric engineers, and others have been brought in to function in their fields under the unified administrative control of the key administrative positions of the Forest Service—Forest Ranger, Forest Supervisor, Regional Forester, Forester.

At the same time the Forest Service recognized that for certain types of specialized advisory service it was more economical to draw on the personnel of other Federal agencies than to duplicate these services in its own ranks. Thus the cooperation of forest pathologists from the Bureau of Plant Industry, forest entomologists from the Bureau of Entomology, meteorologists from the Weather Bureau, biologists from the Biological Survey, soil experts from the Bureau of Chemistry and Soils, and others, has been extensively utilized. In some cases these experts have been detailed to the Forest Service permanently, though reporting to their respective chiefs. In either case these technicians have functioned in an advisory capacity. The advisory experts have determined facts, made recommendations, and in some cases supervised operations which the administrative heads of the Forest Service instituted on the basis of expert recommendations.

The most conspicuous public advantages of this plan of unity of purpose and undivided control have been:

1. The Forest Service as the agency responsible for the management of the national forests has had a free hand to harmonize and coordinate all the activities. No activity is an end in itself, but is merely a means of accomplishing a larger objective in correlated land management. No activity has been on an independent footing to follow its own course regardless of the composite objective of national-forest management.
2. The Forest Service has had the full advantage of the best available expert service without duplication, and without losing sight of the fundamental fact that the expert service was a means and not an end.
3. The constant contact with advisory experts has helped very greatly in effecting continuous improvement in land management.

Any move toward breaking down this plan of unified purpose and single authority by introducing the functional organization idea would be a move away from the public interest. Superficial consideration sometimes prompts proposals to separate activities which seem to be a logical part of the field of a functionalized organization. For example, the national-forest organization handles the construction and maintenance of trails and of simple dirt roads intended primarily to furnish access for forest-fire fighters. Crews working on these projects are made up of local men chosen for their fire-fighting ability as well as for usefulness in road and trail construction, and they are used for fire fighting whenever needed. For this purpose they must be at the instant call of the forest officers. If this sort of work were turned over to a separate engineering bureau it would at once lessen the value of the crews for emergency fire fighting by dividing the supervising authority, and it would also increase the cost of the activity by duplicating in part the overhead already available in the Forest Service, which handles this job in combination with many others.

TIMBER USE

On the national forests are found representative stands of every major forest type in the United States, except the hardwood stands of the Central States, the bottomland hardwoods of the Mississippi Delta, and the coast redwoods of California. Quantitatively, the most important national-forest timber resources are in the Douglas fir, ponderosa pine, western hemlock, sugar pine, lodgepole pine, and Engelmann spruce stands. Qualitatively the white and Norway pine of the Lake States, the Port Orford cedar of Oregon, the western white pine of Idaho, the sugar pine of California, and the cypress of Florida bring the highest stumpage prices. The total stand of national-forest timber of saw-timber size is estimated to be 552 billion board feet, of which 357 billion are in the three Pacific Coast States and 189 billion in the Rocky Mountain States.

Part of this is now economically inaccessible because of location, quality, etc. How much of it will ultimately be available depends upon economic and utilization developments which cannot be foreseen. This wide distribution of the national forests among most of the major timber types provides the opportunity to develop and test at first hand principles of silviculture and management on all nationally important types except the three mentioned above.

TIMBER MANAGEMENT PLANS

The principal objective of timber management on the national forests is to obtain a steady and continuous yield of wood products best suited to the public need. This may be saw logs to be made into lumber for the general market, as in the Pacific Northwest, box shooks for the huge fruit crops of California, hewed or sawed railroad ties of lodgepole pine from the national forests in Wyoming, for a transcontinental railroad, mine props for Colorado coal mines or stulls for a South Dakota gold mine, a turpentine "crop" in Florida, or maple heels for shoe factories in New England. Or, the market may be a wholly local one, as that of the ranchers in and near the South Dakota portion of the Custer National Forest, where the local timber supply is so limited and the local demand so great that every tree is zealously fostered until ready for cutting. A controlling principle in the disposal of national-forest timber is first to provide for the local need, if dependent on the national forests, before supplying more distant markets.

The disposal of national-forest timber is controlled by formal statements of policy which define the markets to be served, the policy for the sale of the timber, and the general silvicultural methods to be followed in its cutting. Where utilization becomes intensive, so as to require the full output of a management unit or working circle, a detailed management plan is prepared which defines the order in which the various parts of the area will be cut, the silvicultural methods to be followed, and the limitation of cut necessary to maintain the output on a sustained-yield basis. Thus the cutting of national-forest timber is systematized under measures designed both to improve and to perpetuate the stand.

In the Douglas fir forests of the Pacific coast and to a lesser extent in some other types, clear cutting has been the most suitable method to follow. Elsewhere, where the condition of the stand favors the practice, national-forest timber is cut under a system which selects the mature and overmature trees for cutting and leaves the thrifty young trees for growth and later cutting when they in turn mature.

An essential part of the policy is to make the national-forest timber contribute as fully as possible to stabilizing the industries and communities partly or wholly dependent on operations based on national-forest stumpage. A stable forest industry built up in and adjacent to the national forests is desirable for itself, as part of the general economic and social structure, and in the steady market it affords for national-forest timber, thus giving the maximum opportunity to cut the timber at the time best suited to the physical condition of the stands, and to salvage promptly timber killed or damaged by fire, insects, and disease.

Where the public interest will be best served thereby, management plans and timber-sale contracts may require the manufacture of the timber within the working circle, thus insuring both the development of a local manufacturing plant for the national-forest timber and the realization of the greatest local benefit from the business based on its utilization.

For every large timber sale on the national forests, there are hundreds of small ones. In the calendar year 1930, which was a reasonably normal year for the national-forest timber sale business, there were 9,451 commercial sales involving up to $500 worth of stumpage each, and 232 sales for amounts over $500. In addition 5,410 sales at the mere cost of administration, under specific legal provision, were made to homestead settlers and farmers for material needed on the farm. Thus, farmers buy at a nominal cost a load or two of fence posts, a few hay-stacker poles, or logs for a new house or barn to be used in the round or sawed into lumber at a local custom mill. Or, in the slack season, a farmer may take out a small commercial sale for hewed railroad ties which he sells to the local railroad-tie contractor, thus employing himself and his team when they would otherwise be earning nothing. This opportunity to work in national-forest timber on a part-time basis, either independently or for some logger or sawmill men, adds in large measure to local stability of employment and builds up a solid, permanent interest in the national forests.

The Harney National Forest in South Dakota is an example of the union of national-forest management and local welfare developed to the highest degree. Practically the entire forest is under intensive management, with many small timber operators employing local help, buying from local stores, stabilizing local revenues. Most of the small towns in the region of 925 square miles depend chiefly on this business. The local residents are educated to the workings and value of the managed forests, talk management plans and working circles like any forester, and local merchants put up on the main highways signs like this:

> Harney Forest under the present sustained-yield plan will produce 15 million board feet of lumber annually if fire is kept out. Hundreds of woodsmen and their families are employed in harvesting this annual crop. For 35 years this store has served these men as a supply base. We are here to serve them in the future as we have in the past. Do your part. Help prevent forest fires and keep the lumber industry alive.

On January 1, 1932, 21 percent of the national-forest timber, exclusive of Alaska, was covered by detailed management plans. Another 61 percent was covered by policy statements. Thus plans of one sort or another have been made for 82 percent of the timber in the national forests, excepting Alaska. Developments in Alaska have naturally been slower than in the national forests nearer the market and adjacent to private operations. Alaska has the capacity, however, to supply permanently a pulpwood cut equal to a fourth of our current national newsprint requirements, and had it not been for the depression substantial pulp and paper developments would have already been under way there.

In the fiscal year 1930 the cut of national-forest timber for all purposes and all commodities was equivalent to 1,653 million board feet. The sustained yield capacity of the national forests, assuming more complete economic availability, would permit a much larger annual cut.

PROGRESS IN TIMBER MANAGEMENT AND SILVICULTURE

Development of the timber-productive capacity of the national forests would be hastened if cutting could be started at once in all the mature and overmature stands, thus removing the ripe timber, stagnant as to growth, in favor of new growing stands. Two principal considerations prevent the immediate accomplishment of this, even if a buyer could be found at once for all mature timber, which is not possible. First, the sale of national-forest timber is held back so as to avoid adding to the overproduction of lumber and other commodities which has been taking place of late years owing to overliquidation of private timber. National-forest sales involving timber values in excess of $500 are limited to supplying existing sawmills dependent on the national forests and pulp mills for the domestic market; to disposing of killed or damaged timber before deterioration; and to cutting on areas where national-forest timber can be most economically logged with the use of transportation facilities constructed primarily for other timber. Second, American silviculture is still in the developmental stage, and despite great progress there is still much to learn as to methods of cutting to insure the fastest and surest replenishment of the timber stands and their greatest growth in both quantity and quality. Intensive research and practical experience are constantly improving the silvicultural technique, so that there is much to be gained by not rushing the cutting of the public timber.

Aside from the handicap imposed by the fact that silvicultural practice and forest management in the United States are still necessarily in the developmental stage, there have been and still are other major impediments in the way of full attainment of the forest-cultural aims.

The adverse effect of the interspersion of privately owned timberlands has already been referred to. Unity of purpose in management is essential to obtaining the maximum benefits from a given working circle. The presence of private timberlands, which are usually cut under a plan of "clean up and get out", offsets in part the benefit of properly handled stands on adjoining national-forest lands. Protective measures against fire, insects, and disease are often ineffective unless prosecuted on all lands in a given unit, regardless of ownership. In some cases the private timber controls both the logical access for logging purposes to the entire unit and the feasibility of developing transportation facilities, thus making harvesting of the public timber await the development of the private tract. Or, conversely, the cutting of national-forest timber may be forced prematurely by the exploitation of the intermixed private holdings, in order to avoid depreciation in stumpage value of the public timber.

This handicap operates chiefly in the extensive tracts of large-size timber on the Pacific coast, where until recently expensive logging railroads and heavy machinery have been thought essential for practical logging. To justify the investment and operating expense, it has been necessary to have control of virtually all of the timber in the unit. Of late, however, the possibilities and in many cases the financial advantages, of tractor or light gasoline donkey logging, and truck hauling of logs to the mill or main-line railroad, have become apparent for so many different conditions that a way is seen to give much greater flexibility to national-forest management by the construction of truck roads which would give access to timber bodies heretofore held for railroad development. Such a publicly controlled transportation system, installed when and where the conditions are favorable, would permit logging public timber independently, in much smaller lots, when opportune from the standpoint of market and physical condition of the timber, or promptly after damage by wind, fire, insects, or disease. It would also permit more to be done in the way of thinning growing stands, utilizing the trees more closely, and partial cutting for special products where desirable. So far, most of the national-forest road construction in this region has had to be primarily for fire protection, calling for locations often not suitable for log hauling.

The advantages of this system have been proven in the other national-forest regions, where access is much easier, and where small sales can be made much more freely during normal economic periods.

One means of lessening the handicap of private timber interspersion lies in the possibility of private and public ownership joining hands to manage the combined holdings in logical units under suitable forestry practice and for sustained yield. The allocation of national-forest timber to purchase by an adjoining private owner in return for his commitment to proper management of his own holdings has been advocated by a number of leading private foresters and by the Timber Conservation Board. It has been proposed that Congress authorize the Forest Service to enter into such arrangements where clearly in the public interest. While this would appear to involve some departure from the open competition feature of national-forest sale practice as established by Congress, the actual present situation is such that often only one operator bids. The present provision in law that no national-forest timber shall be sold at less than its appraised value would safeguard the public interest in the financial aspect of the plan.

Apart from the question of accessibility, the limitations of markets open only to material above a certain minimum size and quality, or of certain species of trees, have prevented intensive silvicultural treatment. Thus the lack of market for lumber of so-called inferior species like white fir in California, white fir and larch in Oregon, and the Rocky Mountain type of Douglas fir and of larch in north Idaho, has required leaving uncut many trees of these species intermixed with trees of more valuable species, or avoiding pure stands of these inferior species within units containing better species. This results in materially falling short of putting the timber stands in the most favorable condition for future growth, postponing this possibility until the next cut, many years hence. Studies in California, for example, show a larger net growth in the remaining stands in mixed stands where the white fir was heavily cut compared with those in which it was cut lightly. Likewise market limitations often prevent use of the small trees or smaller parts of the large trees, thus preventing thinnings in young stands to accelerate growth of the remaining stand.

In New England and Arkansas worthless hardwoods of some species or tree forms often greatly retard the growth of valuable conifers. Though the girdling or cutting of these hardwoods may be accomplished in timber-sale cuttings, these come infrequently and are inadequate in extent to cover the ground rapidly, with the result that valuable growth is materially held back over large areas. It would be both silviculturally and financially advantageous if funds were available for the removal of these hardwoods whenever such treatment is needed. Similarly, improvement of the mixed hardwood stands on the best sites in the Appalachians by thinnings and removal of the worthless trees would be profitable.

Throughout the national-forest cutting areas it has been the practice to require timber purchasers to cut down trees worthless because of disease or other cause, thus ridding the stands of trees which would spread disease to others and improving growth conditions. The cost of this work has been allowed for in fixing stumpage values. In the California national forests, for example, fully 200,000 acres of cutting area have been thus treated.

Disposal of the slash left from timber-sale cuttings has long been a problem. Where the fire hazard is relatively low, as in the central and southern Rocky Mountains, the limbs can be lopped from the tops and left scattered on the ground, thus improving soil conditions as they decay, and either improving or offering no obstacle to the chances for natural reproduction to come in. In the northern Rocky Mountains in Idaho, and throughout Washington, Oregon, and California, fire protection has appeared to require piling and burning of the slash except in the coast Douglas fir stands where broadcast burning is required. This is expensive and silviculturally undesirable in its effect on natural regeneration. Experiments in partial piling and burning, with increased protective measures in other ways, are being tried in representative California pine stands, and may develop a compromise method less costly and more desirable silviculturally. No such prospect is immediately in sight for the broadcast-burned Douglas fir slash problem, but the possibilities of selective logging by area, leaving more uncut timber to constitute breaks in the large slash area, may make it possible to leave a considerable portion of the slash areas unburned.

This selective-logging development also bids fair to help materially in solving the problem of leaving adequate seed trees in the hitherto clear-cut Douglas fir areas. The first plan of leaving individual trees was largely unsuccessful because of loss through their being blown down, or being killed by the slash fire or subsequent accidental fires. A modified plan of leaving trees in strips or groups has been more successful, but not wholly so. If the selective-logging principle proves capable of general application, many stands of present low market value will be left well distributed throughout the cutting areas, awaiting future cutting, and the seed supply problem will be largely solved.

One major objective in the development of national-forest cutting systems is to obtain adequate reproduction following cutting. On many selectively cut areas the stand left constitutes the major part of the desired stocking, and extensive reproduction is not expected until after the second or third cutting. Elsewhere, where thinner stands have to be left, or larger openings made, prompt restocking is the aim; as it is invariably where clean cutting is practiced. Both systematic examinations and extensive observations on cut-over areas show that in general after a reasonable lapse of time, usually not more than 10 to 15 years, restocking is satisfactory on 85 to 100 percent of cut-over land. There are exceptions to this in the Engelmann spruce type of the northern Rocky Mountains and in Arizona and New Mexico, where not more than 50 percent success has been obtained.

The same is true of the Douglas fir type in Arizona and New Mexico, and to a small extent in the ponderosa pine type in extreme southwestern Colorado. An even smaller percentage of successful restocking exists on small areas of jack pine cut-over land in Michigan. None of these exceptions, however, constitutes an important situation, but they do challenge foresters to solve the problem.

Fire, of course, has wiped out the reproduction on some sale areas, but except in the Douglas fir type in the Pacific Northwest and in white-pine areas in Idaho, fires on cut-over areas have been of small consequence. In those two regions the protection of cut-over areas, though less troublesome than on outside lands, has not been fully accomplished, owing to the extreme fire danger prevailing in the region in general. Nevertheless the losses on sale areas have not been great.

In the pine forests of California donkey logging, even with the restrictions in effect on the national forests, caused too much damage to young growth. The substitution of tractors for donkeys on national-forest sales has reduced the damage 25 to 50 percent, so that it is now well within reasonable limits.

REPLANTING

This activity is lagging for want of adequate funds. Though the aim of national-forest management and silviculture is to renew the forests by natural restocking to the fullest possible extent, there are approximately 2,100,000 acres of national-forest land chiefly old burns, which require replanting if the area is to be restocked within any reasonable period. At the current rate of between 25,000 and 30,000 acres annually it will take at least 70 years to catch up. Only 235,000 acres have been planted to date, in the 27 years of active national-forest administration. Though many planting problems are still being studied, the technique of planting has been pretty well developed, the cost in general reduced to reasonable figures, and there is no reason why it should not go ahead. Despite much planting effort to date that must be charged to experimentation, at least two thirds of the planting shows an acceptable degree of survival. Direct seeding has not so far succeeded, and has been temporarily abandoned, though experiments are still under way. An annual appropriation for planting of at least $400,000 should be made available as soon as the financial horizon clears, and it should be stepped up each year to reach $1,600,000 in the fourth year and at least that much each year thereafter. Early replanting is particularly important on the eastern national forests, close to the areas of heavy timber consumption. Some of the land purchased in this region was bought at a low rate for the express purpose of replanting.

Thus a review of the timber-management situation on the national forests shows a number of handicaps still prevailing—for example, the fact that silvicultural and management technique is still in the formative stage; the complication of interspersed private lands; the lack of a road system and market possibilities needed for complete flexibility of management, silviculture and utilization; lack of adequate funds for cultural operations and for replanting denuded areas.

On the other side of the picture is ample evidence of progress—such as the development of management plans which bring all present knowledge to bear on the orderly development and systematic handling of the utilization of the timber resources in the interest of permanent productivity and both local and national public welfare; silvicultural practices which do much to improve the stands and, with minor exceptions, obtain regeneration; improvement of logging methods to more fully protect young growth; the possibilities of selective logging in improving seed-tree reservation; the promise of improved slash-disposal methods to benefit both the expenditure budget and the silvicultural objectives. After discounting for the mistakes inevitable under the trial and error necessitites of a new enterprise, and weighing the present and prospective handicaps, it may be fairly said that American forestry has given a good account of itself on the national forests, even though it has a long way yet to go.

FORAGE USE

When the national forests were created a heavy use of their forage resources was already established under the prevailing custom of unrestricted use of public lands for grazing range livestock. This use was wholly unregulated and involved a mixture of well-established occupation by nearby ranchers and more transient tenure by nonresident herds of cattle or bands of sheep driven in from distant winter ranges. There was a good deal of battling among users to maintain their asserted rights.

The Forest Service set up a system of controlled use, under permit, giving priority to those longest established on the ranges and most dependent on the national-forest grazing resources by virtue of adjacent home ranches. At all times the small local stock raiser, owning his own ranch, has been favored.

Out of this system has grown a large degree of stability in the use of the national-forest range resources. Within or adjacent to almost every ranger district may be found thriving agricultural communities whose prosperity is mainly dependent upon the stable production of livestock. Climate, soil, and location combine to make this the most profitable form of agriculture. In many, if not most cases, it is the only practicable form. Small in area, the farms within these communities are incapable of sustained production without the aid of complementary ranges lying inside the national forests. It is these ranges that provide feed during the season of the year when cultivated crops on the farms must make their growth. It is also these ranges with their power to produce high-quality lamb and beef at a nominal expense that offset the more expensive production and feeding of cultivated crops and make the whole operation profitable. Without the use of these ranges farm lands would have to be abandoned and community life disappear. The fact that more than 4½ million acres of improved farm land and 22 million acres of grazing land are used in connection with forest permits emphasizes this statement.

The fact that the use of national-forest range is made dependent upon the ownership of ranch property of an area and character suitable for farms induces a degree of stability in the business not found in any other part of the range livestock industry. Owners may and often do go out of the business, but the improved lands and farms remain productive under new ownership.

About 83 million acres of national-forest land are used by domestic stock for an average period of approximately 5 months. Owing to favorable topography, good water supply, and a wide variety of vegetation, this land furnishes ample feed as the season advances from early spring to late fall. Year-long use of the range is provided extensively only in the Southwest.

Of the usable range it is estimated that about 40 million acres are timbered, 20 million acres woodland, 20 million acres grass, with brush and burns making up the balance.

For the calendar year 1931, 19,388 permits were issued for 1,338,373 cattle, 37,335 horses, and 431 swine. For the same year 6,319 permits were issued for 6,593,583 sheep and 14,645 goats. The total number of stock grazed in 1931 was the lowest for the past 6 years. Lowered range capacity due to the drought during this period was responsible for four fifths of the reduction in numbers, and miscellaneous causes such as closure of areas for various purposes, voluntary reductions, adjustments due to land exchange, etc., accounted for the balance.

Over the years the use of range by domestic stock has had to be adjusted to provide for the needs of other resources. In 1931, 1,334,659 acres of usable range were closed for recreation, 2,785,198 for game, 719,492 acres for watershed protection, 191,902 acres for timber protection, and 121,416 acres for other purposes.

RANGE MANAGEMENT

The forage resource lends itself to systematic management and cultural treatment in the same way as does the timber. It is the objective of range management to raise the productivity of the forest ranges to the maximum and to regulate their use both in the interest of the stock raiser and so as to avoid impairment of the value and enjoyment of other resources. Thus grazing must be so limited as not only to avoid damaging the forage resource itself, but also to avoid starting erosion, to exclude stock from heavily used recreational areas, to leave adequate forage for game, and, above all, to prevent damage to young forest growth.

Range management plans are prepared or under way for each of the 4,005 cattle and horse and 4,859 sheep and goat allotments. These plans are both written and graphic. They prescribe the class of stock to which the range is best adapted, the number of stock to be allowed, the season best suited to growth requirements of the vegetation, and the manner by which the stock will be handled to secure uniform distribution and utilization, and to avoid conflict with other important uses of the forest. The plan of management also takes advantage of natural features which influence the movement or control of stock, and prescribes such improvements as fences, water development, bridges, corrals, and pastures as are necessary to facilitate management. Seventy-eight percent of the cattle and horse and 80 percent of the sheep and goat allotments were handled under plans during 1931.

The effectiveness of such plans is indicated by the fact that the majority of the ranges are properly stocked and have reasonably satisfactory distribution, and nearly 90 percent have satisfactory seasonal use. While these plans are the result of experience and investigation, and are developed in cooperation with the permittees, the inherent prejudice on the part of owners to changes recommended is one of the most difficult obstacles to overcome. Furthermore, reliance for the execution of the plans all too often must be placed on hired labor of low quality. The burdens of ranch work and other business interests often detract from the interest taken by permittees in their stock while on the summer range. This inevitably leads to confusion and difficulty in dealing with individuals other than the owners. Despite these handicaps, real progress has been made in obtaining the cooperation of the stock owner in the systematic management of his allotment.

The successful application of plans, however, and the development of the resource, is largely dependent upon the construction of improvements and artificial reseeding of important areas, for which adequate funds are not available. Though considerable progress has been made, largely through cooperation by the permittees, in the erection of stock control works, such as drift fences, water developments, driveways, trails, corrals, and salt troughs, and in the eradication of poisonous plants, there is still over $1,250,000 worth of this sort of work to do. Further, as a means of preventing heavy damage to the range itself, an estimated further expenditure of $750,000 is needed during a 10-year period to control the activities of destructive rodents on 5 million acres where heavy infestation occurs.

One of the greatest handicaps, if not the greatest, is the insufficiency of scientific data on which management can be based. There is need to know more about the extent to which the important species of vegetation can be grazed without injury; how depleted ranges can be restored most effectively and most rapidly under use; what adjustments in normal stocking of ranges must be made because of recurring droughts, or critical timber, game, or watershed situations; and many related questions. These all involve intensive research, pending the result of which we must of necessity resort to trial and test.

The use of the forage resources of the national forests has a value beyond its worth to the livestock industry and the communities that industry supports, and beyond the revenue accruing to the Treasury from permit charges. There is a very real contribution to fire prevention and control through removal of grass which, when dry, is easily inflammable and spreads fire rapidly. Countless instances attest the value of heavily grazed stock driveways, for example, as fire lines, and of the greater ease of control of fire on grazed areas than on ungrazed areas. There is also the advantage of checking herbaceous growth which competes with tree seedlings for moisture and light.

No phase of the national-forest enterprise proves more conclusively the worth of regulation and management than that dealing with range management. Out of an uncontrolled and often chaotic condition of early occupation of the ranges has come regulated use. Many ranges which were once tramped into dust by sheep before midsummer are now grazed moderately and left in the fall with the making of next year's crop intact. A long standing and very troublesome problem of damage to forest reproduction over large areas in Arizona mainly from range overstocking has been largely overcome and the forests are now replenishing while livestock still use the area. Much progress has been made in stopping early erosive processes.

As a general summary of the results of management, it may be stated that, while there is still much to learn and to be accomplished, a poor range condition is the exception rather than the rule as it was at one time. The main problem in range management for some time to come will be the healing of "sore spots" here and there.

WATER CONSERVATION

"Securing favorable conditions of water flows" was one of the two major purposes of the national forests as stated in the act providing for their creation, and for the enactment of the Weeks' law provision for purchasing national-forest lands on the headwaters of navigable streams. It has been one of the controlling aims in setting up provisions for and restrictions on the use of national-forest resources and in cultural operations relating to timber and forage.

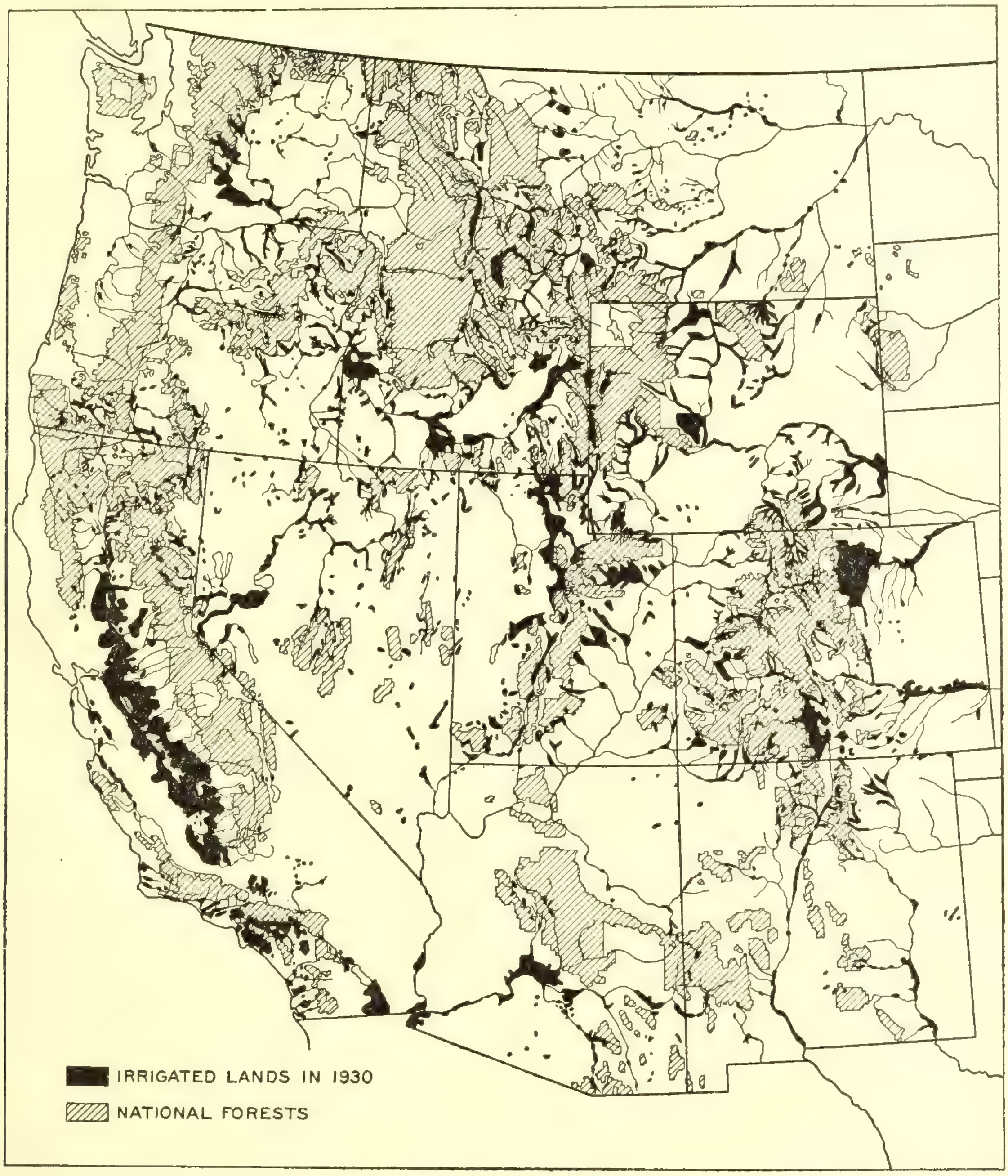

Figure 3.—Virtually every major stream west of the Great Plains, and most of the minor ones, head in a national forest and supply a large part of the water for the great irrigated land areas.

Virtually every major stream west of the Great Plains, and most of the minor ones, head in a national forest. The western national forests contains a large part of the most important western water supply area. From these watersheds flows water which is the indispensable basis for the rich irrigated farm and orchard developments found in practically every Western State. Figure 3 shows the location of the national forests with reference to irrigated lands. Except for irrigation, many of the eastern national forests have similar watershed importance, and are particularly involved in the protection of the watersheds of navigable streams.

A few examples will illustrate the size of the values arising from or potential in water coming from national forest watersheds:

For their domestic water supply 49 cities with a population of 10 thousand or more each, and a total population of nearly 5¼ million, and 327 cities with less than 10 thousand population each and a total population of over 714,000, depend on national forest watersheds. The investment by these cities in their water plans approximates $493,703,000.

Of the estimated 38 million potential horsepower of water power in the United States, a little over 11 million, or 29 percent, is in the national forests. Already 1,618,000 horsepower has been developed on the national forests which, at an estimated investment of $200 per horsepower, gives a present total investment of $323,625,000. Of the total potential horsepower on the national forests, 78.3 percent has been either developed or applied for, and this will involve an estimated investment of $1,742,000,000.

Within the 11 principal national-forest States in the West, the 1930 census shows slightly over $932,000,000 invested in irrigation enterprises. Approximately 89 percent of this sum is estimated to be based on water from national-forest streams, or an investment of $827,500,000.

Thus for domestic water supply, power, and irrigation national-forest watersheds are already providing water for projects involving a total investment of $1,644,828,000.

It is impossible, of course, to ascribe an exact part of these values to the fact that the watersheds are within protected and managed national forests, or to measure exactly the effect of good or poor management of the timber and forage resources on the maintenance of these values. There is so much evidence to show that unregulated timber cutting and livestock grazing, and uncontrolled fire, on watersheds, often cause adverse effects in the form of premature run-off, floods which destroy crops and property, and erosion which fills irrigation ditches and reservoirs and reduces or destroys soil productivity, that it is unnecessary to reduce it to refined quantitative expression in order to make a clear case for the need of regulated use and cultural operations which will preserve and enhance the watershed values of the national forests.

So, timber cutting is invariably regulated by the watershed factor; grazing managed with one major objective to avoid watershed damage; replanting of watersheds given first consideration; the public and livestock excluded from watersheds where necessary to protection of the purity or palatability of the water for domestic use.

RECREATION USE

Because of their wide distribution, their highly diversified topography, elevation, and cover, and their myriad manifestations of natural phenomena, the national forests present large opportunities for public use for purposes of residence, recreation, and education. Such uses, properly coordinated with the other uses and services of the national forests, do not conflict with the protection, management, and development of these public properties. They benefit many millions of people, create additional taxable resources, yield a substantial annual return to the Treasury, and yet involve only a minor percentage of the national-forest lands. Extreme care is taken to prevent any monopoly detrimental to full public use of the national forests, or the establishment of any adverse rights. All exclusive occupancy under permit is carefully planned and safeguarded by appropirate contract provisions.

The public early discovered the recreational opportunities in the national forests and has been taking advantage of them in rapidly increasing numbers. Though it is obviously impossible to obtain an exact count of national-forest recreationists, forest officers have been able to get a very fair approximation of their number by periodic counts at established points, tourists registers, etc. Despite the room for substantial error and for duplication of count, these figures give an excellent idea of the growth in the recreational use of the national forests. For 1917 the estimate of national-forest visitors was 3,160,300; for 1931, over 32,000,000—a tenfold increase. Of the 1931 visitors, 493,235 were occupants of permitted residences on the national forests, or their guests; 1,618,510 were guests at hotels and resorts; 2,193,843 were campers; 3,765,027 were picnickers; and 24,037,428 were transient travelers on or across the national forests who may or may not have made casual stops.

Recreational use assumes many forms. There is the family which wishes to make its summer home in the national forests, by a stream or a lake, or just "in the woods". There are 11,583 permits for residence cabins of this sort in existence, covering structures ranging from a simple 1-room cabin to much more elaborate dwellings with their own light plants and water systems.

Then there are the fishermen, the hunters, the berry pickers, the hikers, the picknickers, and those who "just camp". For those who desire that form of living there are resort developments with bungalows and hotels, and 933 resorts of various sorts are covered by the permits issued to December 31, 1931.

Municipally operated camps have been developed under permit in some of the national forests, notably in southern California, where city residents may enjoy a 2 weeks' vacation at low expense. There is room for much of this development.

In order to retain a suitable proportion of the outdoors in as nearly its original state as possible, where those with pack horse or back pack may find areas possessed of only the primitive transportation facilities—trails or the way wholly undefined—the Forest Service has so far designated 54 primitive areas, totaling 9,018,298 acres, embracing nearly every typical natural condition. Here, where the economic resources are limited, the plan is to keep out public roads and other developments smacking of civilization.

As a means of providing for the large number of campers places where they may camp under sanitary conditions and build fires safely, simple camp grounds have been prepared containing simple toilets, crude fireplaces, garbage disposal facilities, and safe drinking water. This is a joint recreational and fire-protection development, and is highly valuable for the latter purpose in its concentration of forest use involving camp fires. The need for this form of development is far from filled by the 1,800 camp grounds already developed. About 2,300 more are needed, at an estimated cost of about $1,800,000.

Another need is to amend the act authorizing term permits. This now allows the issuance of permits for periods up to 30 years, for not more than 5 acres of land each, for summer homes, resorts, and similar developments. For many of the hotel and like developments needed for the full enjoyment of the national-forest recreation opportunities, 5 acres is not enough. The act should be amended to enlarge the area which may be permitted to not over 80 acres.

Because of its correlation with other phases of administration, the cost of administering the recreational use of the national forests, per visitor and in total, probably is and will be much below the cost under any other practicable form of public administration.

Recreation is obviously one of the major uses of the national forests. In the Western States a large part of the area where forest recreation may be enjoyed is in the national forests. The Superior National Forest in Minnesota embraces some of the finest canoe country in North America. The recreational use of the White Mountain National Forest in New England is heavy. It is the view of the Forest Service that the recreational advantages of the national forests should be widely enjoyed, that recreation should be fully recognized as one of the major resources of the national forests, and that the recreational use should be so coordinated with other uses as to avoid conflicts which would undesirably impair any important values.

Every effort has been made to translate this view into active policy. On the one hand specific provision has been made for facilities needed by recreationists through permits for residences, resorts, municipal camps, and similar developments; camp grounds have been developed; the location of especially attractive recreational features shown and described on map folders issued to the public in connection with the educational campaign in fire protection; part of the public-road system on the national forests has been constructed for access to recreational areas; timber cutting has been modified or excluded from areas where the recreational and aesthetic values are high or paramount, such as around lake shores, along highways, in summer-home colonies; grazing of livestock excluded from meadows needed for campers' horses, immediately around camp grounds, and where chosen areas containing unusual wild-flower displays are to be safeguarded. On the other hand, recreationists have been excluded from municipal watershed areas where necessary to avoid danger of contamination of the water supply, and from areas of exceptional fire hazard; recreational developments are not allowed to obstruct the only logging access to large bodies of timber, nor to intrude on the borders of highways or lake shores so as to impair esthetic values. The whole effort has been to direct and regulate the recreational use to the extent needed in a general plan of correlated use of all resources, with the minimum restriction on the freedom of the recreationist to use the national forest in his chosen way.

In order that there may be adequate authority for the Forest Service to make modest expenditures for some expert assistance in planning the proper development of the areas possessing outstanding scenic or recreational quality, and for the other things needful in properly handling the ever-increasing recreational use, it is desirable to have specific congressional authorization along those lines.

Legislation in about the following terms is recommended:

That in the administration of the national forests under the provisions of the act of March 3, 1891 (26 Stat. 1103), and acts amendatory thereof or supplemental thereto, and in coordination with the activities authorized by such acts, the Secretary of Agriculture may, and he hereby is authorized to, take such measures as he may deem necessary to develop and make available for public use and enjoyment the recreational, educational, and related values of the national forests so far as may be compatible with the purposes for which they were created, and with the proper consideration of their scenic and wild life resources.

WILD-LIFE PRESERVATION

GAME

The national forests contain about 75 percent of the range of the big-game animals of the 11 Western States. They are also the principal fur-producing areas in these States. They provide sport for a half million hunters, by whom some 100,000 big-game animals are killed annually. They constitute the largest and the best game area under public ownership where the American system of hunting can be perpetuated. In addition to the value of game to the sportsman, economic and æsthetic considerations justify development of the resource. The addition to local business arising from expenditures of sportsmen is an important factor in many communities. The sale of hunting and fishing licenses is an important element in State and county revenues.

Game production is a recognized form of land use in the administration of the national forests. The same systematic planning that is applied to the production of timber, forage, and other resources, is essential to the development of game, and is being developed. There is one great difference, however, between game management and the management of timber and forage. In the latter, management is carried to the removal of the crop from the land. In the former, Forest Service legal responsibility ends with the development of plans. This is due to the division of responsibility between Federal and State Governments which has grown up under the common law and which imposes upon the latter and denies to the former regulatory authority. The authority of forest officers is contained in the act of May 23, 1908, which provides that all reasonable assistance in the protection of game within the national forests shall be given State authorities. Under these circumstances efforts of the Forest Service, in cooperation with the Biological Survey, must of necessity be confined to assistance in protective measures, study of conditions on the ground, the development of plans necessary to meet the specific problems involved, and encouragement and assistance to State officers in the application of those plans. The Forest Service has authority to remove animals when damage to the forest occurs, but cannot insure beneficial utilization of the animals removed.

Under this cooperative policy there have been established on the national forests 289 State game refuges covering almost 21 million acres, and 24 Federal game preserves covering more than 3 million acres of land. These refuges were established at a time when the thought on management began and ended with protection. Years of protection, however, have proved the rapidity with which wild life under the right environmental conditions increases. This has brought into the picture that regulation of numbers of game animals is just as essential as the regulation of numbers of livestock if overgrazing of the range and depletion of the herds is to be prevented. An increase of more than 100 percent in big-game animals generally on the national forests during the past 10 years, and overstocking on specific areas, emphasize the need of applying the same principles to game management as have proved of such benefit to ranges used by livestock, namely, the limitation of numbers to the capacity of the range. The application of such principles is difficult if not impossible so long as the State attempts regulation by laws applying broadly to the State as a whole. Before they can be applied there must be a recognition of the fact that each area is a unit by itself, capable of supporting a given number of a certain species of animals and no more. Until this principle is accepted there will continue to be areas that might support large numbers but are prevented from doing so by over-kill, and other areas where the kill is far less than the productive capacity of the range justifies. The former is a state of unproductiveness, the latter a most destructive form of land use which inevitably leads to overgrazing, with all its attendant evils, and in extreme cases even to final extinction of game.

Better to visualize the problems involved, it is estimated that the national forests now support approximately 12,700 antelope, 50,600 black and brown and 3,700 grizzly bears, 969,000 deer, 97,000 elk, 7,800 moose, 22,000 mountain goats, and 12,500 mountain sheep, and at least 10 important species of fur bearers. Game and nongame birds are also important. As each locality has its own particular problem, so does each species of animal involved. The problem, therefore, of coordinated land use is of some magnitude. It cannot be solved by arbitrary State laws or regulation, but rather by systematic planning and adjustment.

Since both domestic and wild animals subsist on the native vegetation, conflict arises as numbers of either or both classes approach the full capacity of range. This condition brings about the need for adjustment, often in the way of reservation of specific areas for game, but more generally in the way of reduction in numbers of either or both classes.

Adjustments to provide reserved areas are indicated in the discussion of range management and in the statement relative to game refuges. In the latter case, however, total exclusion of livestock is not attempted, nor is it desirable, but the domestic livestock capacity is reduced. This, together with the areas closed for game, is equivalent to about 12 percent of the entire range capacity of the national forests. It should be understood also that some species of game occupy all areas, and that nearly 50 million acres of land in the western national forests which cannot be used by domestic stock because of topography, dense timber, and brush constitute some of the very best game range.

In general, the national forests have ample summer range for present numbers of game animals, and in some cases a large increase could be provided for. But winter range, owing to high elevation and deep snows, is inadequate in most cases for even present numbers.

The needs of the present situation may be briefly stated:

1. More basic knowledge on the life and feeding habits of the various species of animals and birds.

2. Better training in game management of both State and Federal personnel, and some enlargement of the State forces.
3. Adequate plans of management for each natural unit, including regulated kill by sexes and by topographical units.
4. A competent nonpartisan game commission in each State, with full authority to install regulations necessary to meet the needs of wild life and the range.
5. A clearer definition of the responsibility of Federal officers on Federal land.
6. Better provision for winter range at low elevations outside of the national forests or feed.

FISH

Within the national forests there are about 60,000 miles of streams and many thousands of lakes suitable for fish porduction. Better and more roads, with an increase in auto travel, have greatly increased the yearly demand on these waters. This results in a gradual decline in the productiveness of most waters, even though extensive stocking operations are carried on by the Bureau of Fisheries and State fish and game commissions in cooperation with the Forest Service. It is estimated that the yearly planting equals or exceeds 50 million fish.

In cooperation with the Bureau of Fisheries, stream surveys are now under way, and it is expected that complete plans for each stream will eventually be developed, including stocking, rearing ponds, and related measures for building up and maintaining this important resource.

MISCELLANEOUS USES

A review of the almost endless list of miscellaneous uses of the national forests provides an index of the well-nigh unlimited variety of ways in which they lend themselves to economic enterprises or pure enjoyment. There are apiaries and fox farms, artificial fish ponds where trout are raised for market, cabins and courses for skiing clubs, mineral springs developed for the ailing, trappers' cabins, and branding corrals and counting pens used by stockmen. Altogether there are 76 different sorts of uses under permit, a total of 36,457 permits, which bring in around $300,000 each year to the Treasury.

NATIONAL FOREST PROTECTION

FIRE

The steady downward trend of the curve showing acreage burned is the most graphic proof of continuous progress in protection of the national forests from fire. This has occurred in the face of a marked and long-continued deficiency in precipitation in the regions of greatest fire risk; a tremendous increase in human use of the forests; recurring outbreaks of incendiarism, aggravated by unemployment; and the growing hazard due to the steady increase in the acreage of the hard-to-protect cut-over lands immediately adjacent to the national forests and on some of the private lands within their boundaries. In the Douglas fir region of the Pacific Northwest the area of cut-over lands burned is roughly 30 times that of the area of green timber burned.

Figures 4 and 5 contrast the adverse factors of precipitation deficiency and increased human use and incendiarism with the steadily dropping curve of burned area. There are irregularities in this area curve, of course. Especially bad years like 1919, 1926, 1929, and 1931 send it up, but each critical year leaves the protection forces with still greater experience, which is turned to account in meeting the next crisis more successfully.

When the Forest Service assumed the administration of the national forests in 1905 there was no developed technique of forest-fire prevention and suppression in the United States, and very scanty means of action in the form of personnel, tools, and transportation and communication facilities. A steady drive has been maintained to bring these up to adequacy, to educate the public in care with fire in the forests, and to reduce the hazard incident to lumbering, road clearing, land clearing, slash burning, and similar sources of risk. The following indicate the character of the attack on the fire problem:

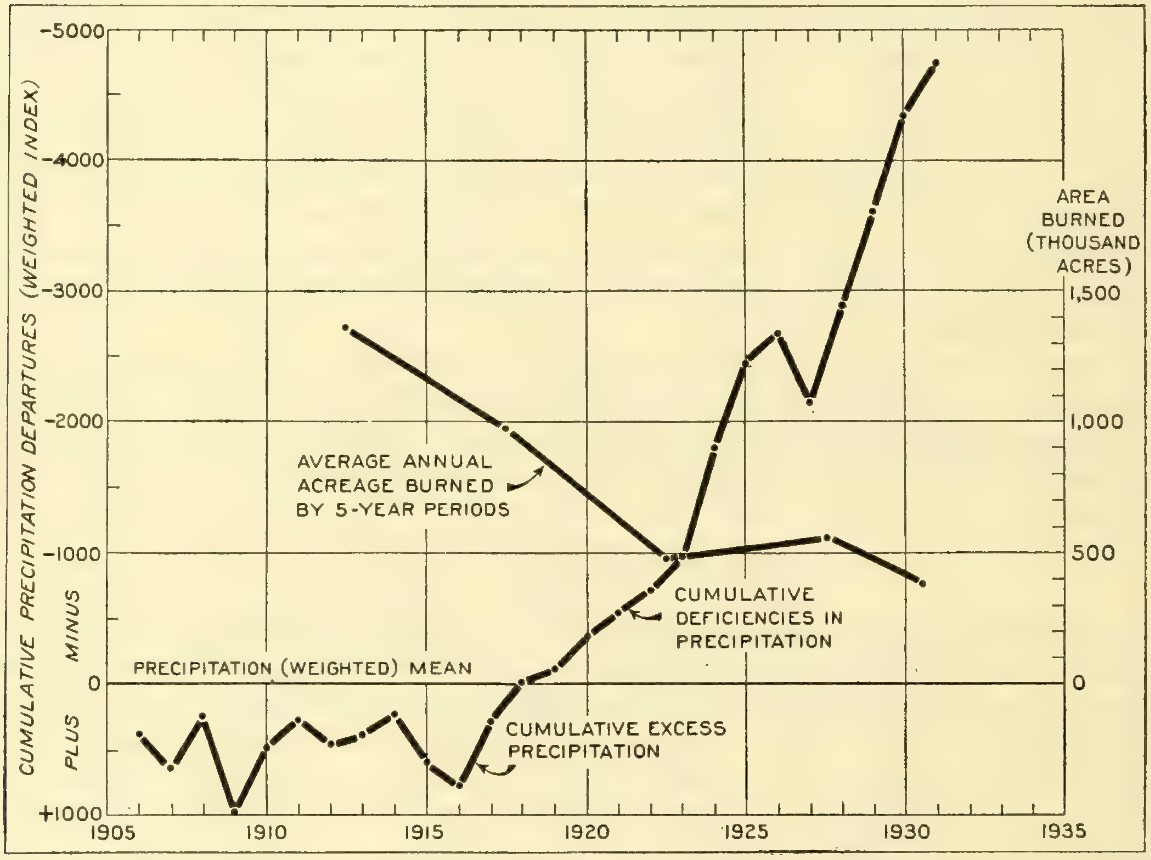

FIGURE 4.—Since 1916 there has been building up a huge deficiency in precipitation in the regions of highest fire danger. While precipitation is only one of the major factors influencing the difficulty of fire control, this accumulative drying out of the forests has had a marked effect in increasing the severity of the fire seasons. Despite the handicap of this 15-year drought, the fire-control campaign has resulted in a down trend in area burned over.

1. Educational activities of many kinds to make forest visitors more careful with fire in the woods and to build up public support of fire prevention and suppression morally, legally, and financially. One very tangible result has been in holding down the number of man-caused forest fires while the number of persons using the national forests has increased manyfold.

2. Regulation of forest travelers where necessary by such means as requiring camp-fire permits, concentration of camping on prepared camp grounds, restriction of smoking in the woods, and requiring camping parties to carry a shovel and ax for emergency fire fighting.

3. Development and enforcement of rules controlling the use of fire in lumbering operations.

4. Systematic analysis of the causes of fires, with attack on specific causes, such as camp fires and railroad fires.

5. Abatement of special hazards in dangerous areas, such as removal of accumulated slash, snag falling, roadside cleaning.

6. Building up a lookout system for prompt detection of fires and a telephone system for quick reports of fires to the control forces. The portable radio is now being developed.

7. Road and trail construction to facilitate prompt arrival of men and equipment on fires.

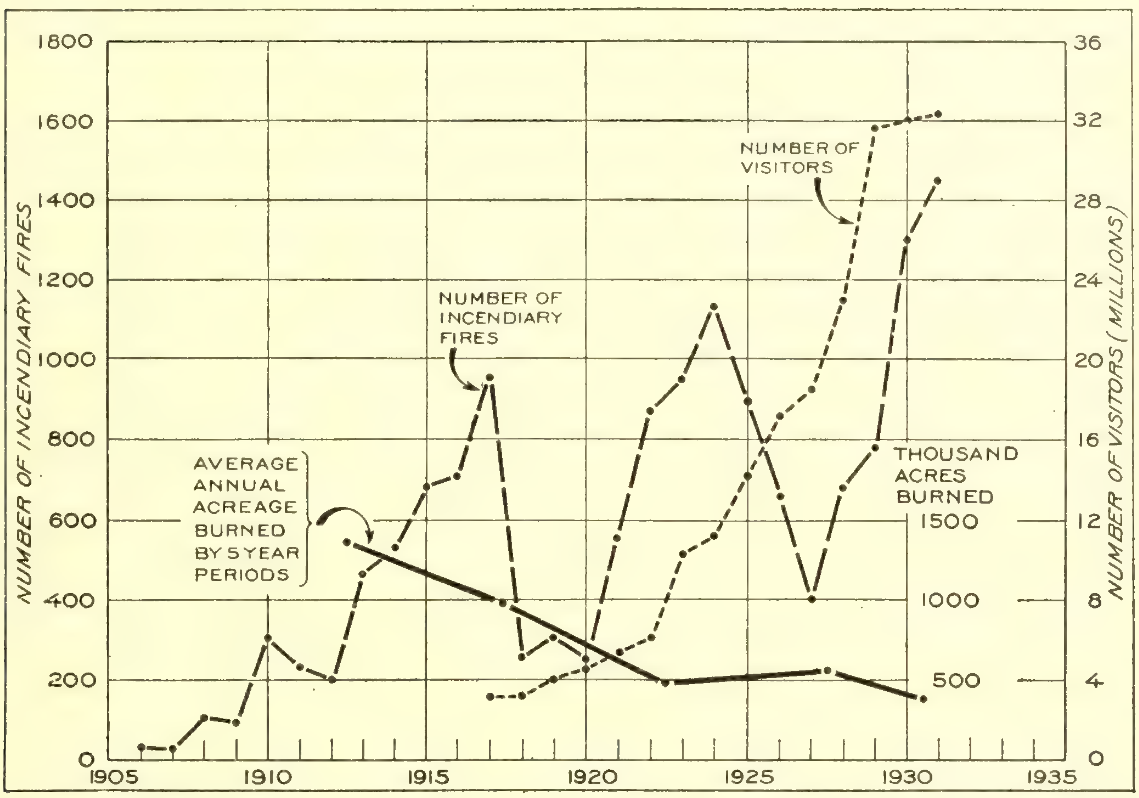

FIGURE 5.—Despite steady upward trends in human use of the national forests and in incendiary forest fires, fire-control efforts have kept the trend in acreage burned moving downward.

8. Gradual increase in the personnel available for detection and first attack.

9. Systematic training in fire control, particularly in suppression technique and the executive management phases of the problem, of both year-long and short-term protection personnel.

10. Preparation and execution of fire-control plans for each ranger district, which include a specific program of fire prevention, detection, and attack.

11. Systematic review of the effectiveness of control action on fires in order to profit by experience.

12. Study of the behavior of fires to determine the required speed and method of attack.

13. Provision of more nearly adequate stores of tools and other fire-control equipment.

14. Development and use of power water pumps, water-tank trucks, fire-trench plows operated by horses or tractors, special hand tools, and lights for night work to speed the work of actually putting the fire out. This use of machinery has been very effective.

15. Preparation of firebreaks where the conditions are suitable, chiefly in the southern California watershed forests.

16. Systematic research directed at all phases of fire control—prevention, preparation, and suppression.

17. Enlistment of large-scale cooperation, financial and otherwise, by owners of private land within forest boundaries, by communities in and adjacent to the forests, and by thousands of local residents who individually and in organized groups act in emergencies to suppress fires. The building up of this local interest in fire protection has done much toward fire prevention as well as in fire suppression.

18. More effective protection by States, counties, and private owners of areas bordering the national forests has helped materially in the protection of the national forests. The Clarke-McNary law cooperation has done much to stimulate this.

The descending curve of area burned is not the only obvious proof of progress in fire control. Pine trees poking their heads up here and there through the dense brush fields of the California foothills attest the progress in solving one of the most difficult fire problems. The advent of young tree growth under formerly parklike pine stands whose floor was kept clean by frequent fires in pre-national-forest days is so extensive that the numbers of livestock grazing on these areas has had to be substantially reduced because trees are taking the place of grass. Old burns are being reclaimed by tree growth.

The fire-control battle on the national forests is far from over, however. Figure 6 shows that protective measures still fail to keep losses within allowable limits on nearly one third of the area requiring protection. Here the average annual burned area is almost five times as great as can be tolerated. More progress is required along many lines—in still more public care with fire and less public indifference to incendiarism and to fires in "brush" which are really burning up young tree growth. The preventable fires from railroads, land clearing, lumbering, and other industrial or business operations have not all been eliminated by a considerable margin; methods of slash disposal still need much improvement; more physical means in men, improvements, and equipment are required; greater efficiency in the manpower must be sought by continued training; active cooperation must be further developed; still more effective action on adjoining State, county, and private lands must be stimulated; a substitute must be found for private protection effort where it has broken down under the overload of cut-over lands; and much more fire research in all lines is indispensable.

Where the highly aggravated brush-field protection problem is as extensive as in California, serious study should be given to the possibilities of hastening the reclamation of the land by the much more easily protected tree growth. This may perhaps be accomplished by planting scattered areas from which the forest cover will eventually spread by natural seeding. Still better would be to find some cheap method of completely replanting with trees these dense brush areas, but so far this has proven too expensive and the survival has been too small.

In order to provide effective fire protection for the 30,028,884 acres of national-forest land still inadequately protected—that is, to hold the average annual burned acreage to a figure which will not defeat the full accomplishment of the resource management plans and objectives—

it will be necessary to continue the development of a road, trail, and other improvement program and furnish and equip some additional

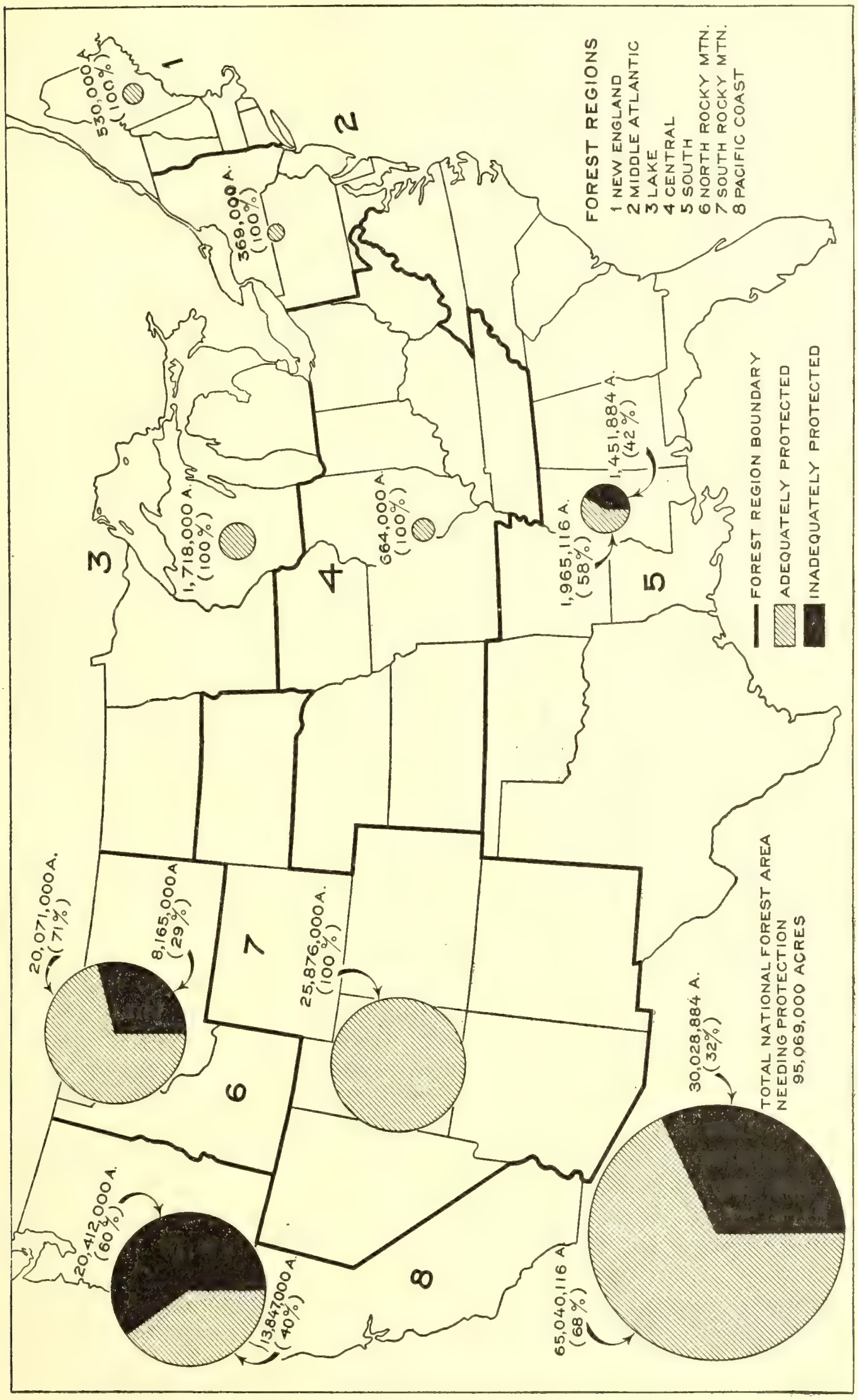
1
530,000 A. (100%)
2
369,000 A. (100%)
3
1,718,000 A. (100%)
4
664,000 A. (100%)
5
1,965,116 A. (58%)
1,451,884 A. (42%)
6
20,071,000 A. (71%)
8,165,000 A (29%)
7
25,876,000 A. (100%)
8
20,412,000 A. (60%)
13,847,000 A. (40%)
65,040,116 A. (68%)
30,028,884 A. (32%)
FOREST REGIONS
1 NEW ENGLAND
2 MIDDLE ATLANTIC
3 LAKE
4 CENTRAL
5 SOUTH
6 NORTH ROCKY MTN.
7 SOUTH ROCKY MTN.
8 PACIFIC COAST
— FOREST REGION BOUNDARY
▨ ADEQUATELY PROTECTED
■ INADEQUATELY PROTECTED
TOTAL NATIONAL FOREST AREA NEEDING PROTECTION 95,069,000 ACRES

FIGURE 6.—Nearly one third of the national forest area which requires fire protection is still inadequately protected because of lack of sufficient means in roads, trails, telephone lines, and other improvements, and personnel.

personnel. A recent study shows that for the next 8 years there should be an annual appropriation of $2,300,000 for the construction of protection roads and trails, and $1,400,000 for the maintenance of the protection system of roads and trails, much of which has already been built. There should also be an annual appropriation of $465,000 for the construction of other improvements, such as telephone lines, lookout houses, etc., and $315,000 for maintenance of such improvements. Beginning with the fiscal year 1935 there should be an appropriation of $80,000 for additional fire guards to compensate for the loss of the fire-protection services of road, trail, and improvement crews withdrawn as construction work is completed. This item should be built up by approximately equal steps each year for the ensuing 7 years, to reach $625,000 annually coincident with the completion of the road, trail, and improvement construction program.

This will result in an estimated eventual average annual protection cost of $6,515,000 compared with the present average cost of $5,438,000. Per acre of protected land the eventual cost is estimated at $0.06853 against a present average cost of $0.0572.

The foregoing figures represent merely the best present forecast. The only proof of effectiveness of outlay is experience. Further hindsight may well indicate a revision of these estimates either up or down.

FOREST INSECTS

Destruction of timber by bark beetles is not spectacular like destruction by fire, but in several national-forest regions loss of merchantable timber from this cause is far greater than by fire. In the pine forests of California, Oregon, Washington, Idaho, and Montana losses have been heavy. Forest entomologists estimate that about 250 million board feet of timber is being killed annually by bark beetles in the California National Forests alone. During the past 10 years, billions of feet of national-forest timber have been killed by concentrated attacks of these insects, with almost no opportunity for salvage before rapid deterioration renders the timber unfit for use.

Where timber values are low and promise to be so for some time, as in the case of some of the lodgepole pine stands attacked by the beetle, it is debatable whether the cost of control is justified. In the higher value western white, ponderosa, and sugar pine, control measures developed in cooperation with the Bureau of Entomology are worthwhile. Because the loss from insects goes on so quietly it has been much less easy to focus public attention on it than on fire losses, and to obtain adequate appropriations for control measures. What is needed is a flexible fund like that used for fire suppression which will enable control action to be undertaken promptly when the need arises, as it often does quite suddenly. The next best thing would be an annual appropriation of at least $200,000, to be used if needed, in place of the approximately $100,000 appropriation such as was made for the fiscal year 1933. Apart from this, the Bureau of Entomology should have added funds for research into the habits of the insects and the most effective means of control.

The more spectacular losses caused by defoliators, such as the hemlock looper, occur much less frequently, give little or no advance warning, and are extremely difficult to control, though dusting with insecticides from airplanes may offer substantial possibilities. To meet emergencies arising from sudden attacks of this sort, the flexible fund is especially important, particularly for further experimental efforts of control.

FOREST TREE DISEASES

The chestnut blight, which in the space of a few years killed nearly all the chestnut timber in the Atlantic Coast States, is evidence of what a forest tree disease can do. The productivity of the national forests in the Appalachians, measured in terms of value of product, has been substantially decreased by the virtual elimination of chestnut. Unhappily no means of control has yet been found. The only present hope for the return of chestnut lies in the possibility of the natural development of a blight-resistant variety among the young growth slowly coming back in spots.

There are other troublesome tree diseases which, though not of major consequence, constitute a certain degree of handicap in timber growing, and, in the case of two important species, may contain the making of a real menace in the future. Of these, the various trunk rots which infect trees injured by fire, logging, or other means, cause a large annual loss of wood by their destruction of part of the merchantable portion of the tree. The amount of material which has to be discarded because of rot when timber is cut often runs as much as 10 per cent of the total volume of the mature stand, and occasionally amounts to a third or more of the volume. Until the present mature and overmature stands are cut and the forests placed under more intensive management which will cut trees before overmaturity occurs and allows decay to become measurable, there will continue to be a large aggregate loss of volume by the continued encroachment of wood decay. Better fire protection and increased care in logging will minimize the attacks of these wood-rotting fungi in the young stands.

Damage in the form of retarded tree growth is caused by mistletoe, abundant in some pine stands in the West. The only practical control measures lie in cutting infected trees as much as possible in timber-sale operations. A form of rust has damaged some of the ponderosa-pine plantations, but not to a serious extent in the aggregate. More serious have been the losses of nursery stock from the "damping-off" fungus, but effective control measures for this fungus have been developed.

The possible menace lies in the potentialities of the larch canker, which has appeared in the eastern larch stands but has apparently been controlled, should it get into the more extensive western larch forests, and in a Douglas fir canker, quite troublesome in introduced stands of this species in Europe, but not yet found in the great Douglas fir forests of the West. Constant watchfulness is required to prevent these fungi from gaining a hold where they might cause extensive destruction.

The tree disease of an immediately alarming nature is the white-pine blister rust, which is rapidly gaining a strong foothold in the western white-pine forests of north Idaho, northeastern Washington, and western Montana, and is spreading steadily toward the sugar-pine stands in California. Both of these high-value species mean a great deal in the economic life of the regions where they are found in abundance, especially in north Idaho, where the entire lumber industry rests chiefly on the white-pine forests. Likewise, the lumber of these species is an important, widely used commodity.

There is a big task on the national forests to eradicate this menace. Part of the job of control is a joint one between Federal, State, and private owners. Appropriations by all three agencies have been made for a cooperative drive to control the pest, which can be done by the practical measure of destroying the wild currants and gooseberries which are the indispensable alternate host of the disease. What has been done so far, however, is wholly inadequate to meet the situation. For the national forests alone, in the north Idaho region, not less than $400,000 per year should be appropriated, and this will probably have to be continued for at least 10 years.

BUSINESS ADMINISTRATION OF THE NATIONAL FORESTS

A major objective of the Forest Service has been to bring the utmost efficiency into the business management of the national forests. The organization has been developed with that purpose constantly in mind, and has been adjusted whenever necessary to promote that object. More economical ways of doing work have been constantly sought. The men of the Forest Service have done much of their own inventing in the development of time-and cost-saving devices. Thus special fire-fighting tools have been developed to lighten the fire-chaser's pack and get him on the fire more quickly; plows have been developed for machine or horse traction to speed and cheapen the construction of fire trenches; a similar method has been adopted for much of the trail construction; notable pioneer work has been done in devising inexpensive machinery to lower the cost of the simple fire protection roads constructed by the Forest Service; a cheap portable radio has been built to afford quick communication with remote fire crews and avoid telephone line investments. In all ways the effort has been to make the public dollar buy the utmost in net public benefit.

While business on the national forests has been growing at a steady and rapid rate, the Forest Service has steadily reduced the number of its ranger districts by putting more territory under one ranger, and has likewise reduced the number of year-long employees engaged in national-forest protection and administration. In several cases two national forests have been combined under one head. Figure 7 furnishes a comparison between 1920 and 1931 in the matter of ranger districts and the entire year-long administrative personnel of the Forest Service, and the major items in protection and administration handled by these employees.

Toward this, several major factors have contributed. One of the most obvious is the much greater facility of transportation by the substitution in large measure of the automobile for the saddle and pack horse, enabling one man to cover much more territory and work in a given time. The great extension of the telephone system has been helpful in expediting business. The formerly sizeable jobs of examining lands applied for as forest homesteads, of examining and reporting on a large number of homestead and mining claims coming up for patent, of getting evidence for action on timber trespass committed chiefly before active administration of the national forests began, of running lines to find out where the national-forest boundaries really were, of making long trips for mail and supplies, have all greatly diminished, leaving more time for more productive business.

Changes in factors such as the foregoing, and in volume and character of work, have been caught up periodically by searching analyses of the amount and seasonal distribution of the work on each ranger district, and of the physical and other factors controlling the accomplishment of the work. Thus overloads and underloads could be adjusted. Systematic cost-keeping has shown the cost of each line of work and each project, and has promptly disclosed opportunities for more economical performance.

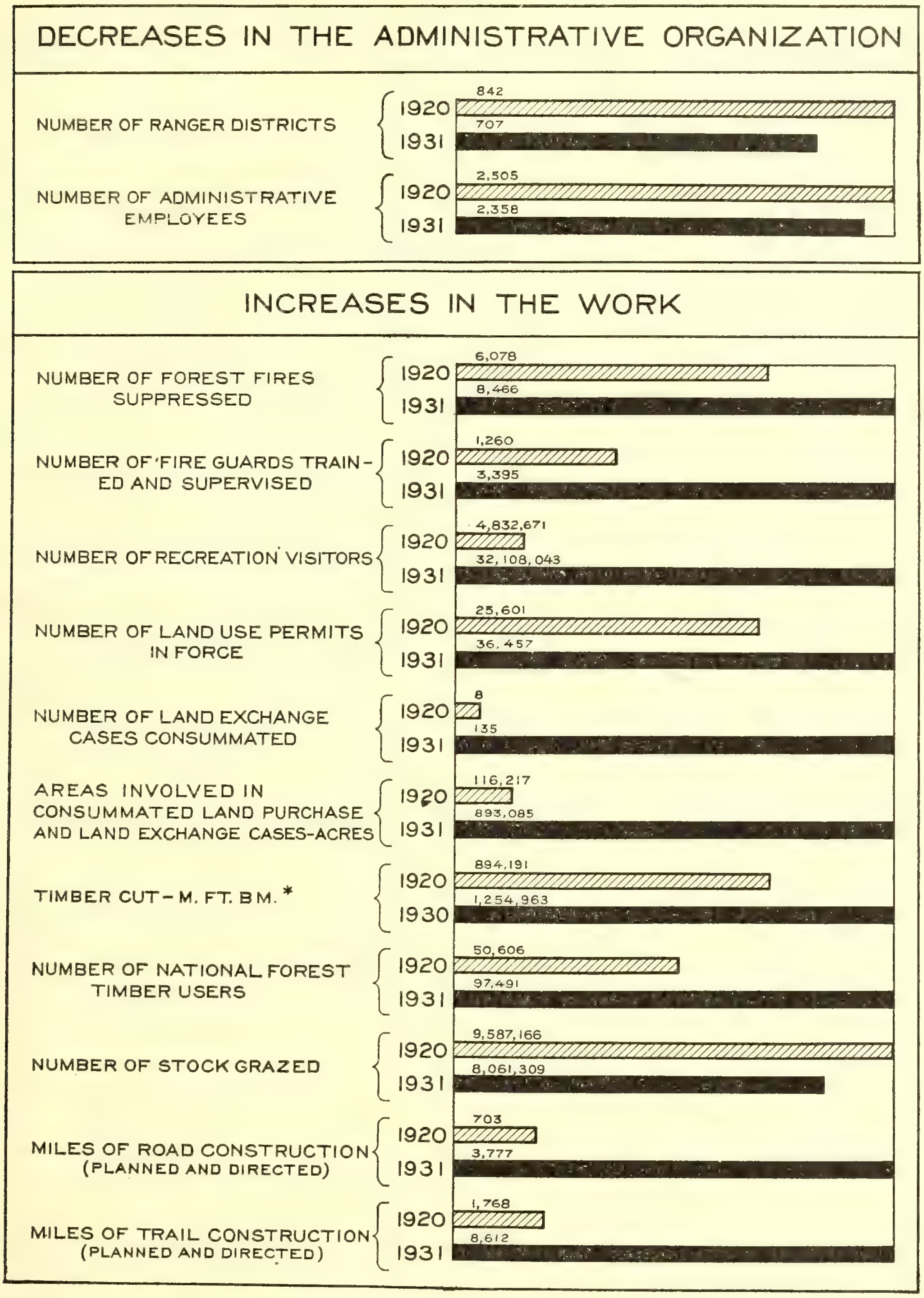

FIGURE 7.—A steadily decreasing administrative organization has handled a steadily increasing volume of work; a comparison between the years 1920 and 1931. Number of stock grazed has slightly decreased, but not enough to measurably lighten the work. (1930 is used for "timber cut" because it was the last normal year for this class of business; 1920 is fiscal year, 1931 calendar year.)

Of major influence has been the persistent effort to systematize and improve performance by the use of carefully prepared work plans which set up a definite scheme for doing the work in the most time-saving way, but always aiming at established standards of quality. Coordinate with this is the training given the entire organization by means of group training camps for both new and old men, meetings for the discussion of problems and adoption of new policies and programs, study courses conducted by correspondence on subjects directly related to the work, and the systematic placing of recruits under capable older men for breaking in.

One reason why these efforts have borne so much fruit lies in the permanency of the wholly non-political organization which it has been possible to build up under civil service appointment and in accordance with well-established, long-time objectives and policies. Too many State forest organizations have been unstable because of political influences or lack of a definite program understood and supported by the public. Too often privately employed foresters have been among the first to be discharged when adversity overtook their employers. Forestry is a job demanding permanence of organization and program.

Coordinate with the permanency of the national-forest organization is the character of the organization. It is one in which there are few single line specialists, but rather men who are trained in the conception of the multiple but coordinated purposes of the national forests, and who are called upon to do well many different sorts of work. Thus the forest ranger marks and scales timber, inspects the grazing ranges, builds and repairs telephone lines, fights fire, lays out and develops campgrounds, and does a multiptude of other things, dovetailing them through the medium of his work plan. This makes for a large saving of time and expense otherwise inevitable under an organization built up differently, along strictly functional lines.

Figure 7, while omitting the less time-consuming activities, gives a good idea of the large volume of work on the national forests in a normal year and emphasizes the importance of systematized execution.

The national forests have not yet become self-supporting. Aside from the expenditures which go into capital investments, such as improvements, planting, fundamental research, and the like, they could easily in normal times be made to pay from income the current administrative and protective costs if the sale of national-forest timber were pushed without regard to the general economic effect of such action, if the grazing privileges were leased to the highest bidder instead of apportioned among those most dependent thereon at a fee fixed at the lower end of the commercial range—and that fee occasionally remitted or reduced by Congress or administrative action when severe drought or similar adversity overtakes the ranges—and if all recreation were put on a charge basis. Table 3 shows the national-forest costs and receipts for the 10-year period ending with the fiscal year 1930, the last reasonably normal business year. This comparison shows that the ratio of receipts to the straight current costs of protecting and administering the national forests, including maintenance of improvements, during the 10-year period never dropped below 55 percent and ranged from that figure up to 99 percent, with a 10-year average of 72 percent. Later, when the timber resources are fully utilized, the current income will undoubtedly substantially exceed the current expense, though some added personnel will be required as the business substantially further increases.

TABLE 3.—*National forest receipts and expenditures, 10-year period, fiscal years 1921–30, inclusive*

Fiscal year	Administration and protection of national forests			Capital investments [2]	Total expenditures	Total receipts	Ratio of receipts to administrative and protective costs
	Fire control	All other [1]	Total				
							Per cent
1921	$1,004,362.25	$5,450,790.50	$6,455,152.75	$1,812,439.81	$8,267,592.56	$4,151,931.42	64
1922	2,251,447.84	3,233,066.92	5,484,514.76	2,567,462.51	8,051,977.27	5,068,527.42	92
1923	2,167,053.40	3,430,892.80	5,597,946.20	4,405,616.10	10,003,562.30	5,335,818.13	95
1924	1,841,376.31	3,442,156.68	5,283,532.99	4,726,943.60	10,010,476.59	5,251,903.11	99
1925	3,764,399.59	3,557,316.32	7,321,715.91	5,336,322.78	12,658,038.69	5,000,137.49	68
1926	2,765,622.58	3,960,204.30	6,725,826.88	6,149,047.58	12,874,874.46	5,155,661.02	77
1927	4,496,379.38	4,950,608.65	9,446,988.03	5,384,254.54	14,831,242.57	5,166,605.74	55
1928	2,835,757.68	5,232,340.96	8,068,098.64	6,108,040.62	14,176,139.26	5,441,434.80	67
1929	3,486,863.62	5,341,716.81	8,828,580.43	5,748,974.04	14,577,554.47	6,299,801.86	71
1930	6,014,738.84	5,591,218.87	11,605,957.71	6,208,764.28	17,814,721.99	6,751,553.22	58
Total	30,628,001.49	44,190,312.81	74,818,314.30	48,447,865.86	123,266,180.16	53,623,374.21	72

[1] Includes maintenance of improvements.
[2] Roads, trails, other improvements, plantations, etc.

This difference between income and outgo for running expenses, totaling approximately 21 million dollars for the 10 years, has been a low price to pay toward the current benefits of the national forests and the values added thereto in part by this outlay. For the period 1926 to 1930, inclusive, the ratio of area burned on the national forests to the "allowable burn" [1] was 1.07, on all forest lands outside the national forests 11.00; the productivity of the timber and forage resources was substantially increased by cultural operations; the recreational opportunities of the national forests were much more fully explored and embraced within systematic plans for their use. Thus the excess of current expense over income was no deficit; it was a dividend-paying investment.

A full commercialization of the national forests might serve the public interests less well than the present policy. It must always be remembered, too, that the national forests create hundreds of times as much income as goes directly into the Treasury from their use. One thousand board feet of stumpage may bring the Treasury $3, but before it has finally gone into a house as lumber or a newspaper as paper pulp it will have been the cause of 10 to 20 times that much money being paid in wages, transportation, taxes, and for supplies and equipment. The steer which grazes on the national forests for 75 cents for the season sells for 10 or 15 times that much per hundred pounds in the fall, and out of that comes wages, taxes, freight, supplies, and after that the packer, the railroad again, and the butcher get their returns from handling the national-forest grass-fed animal. The tourist who camps on the forest, who patronizes a permitted resort, who hunts and fishes, puts money into circulation which multiplies many times the direct return to the Treasury or the cost thereto for supervising his use of the forest. So the national forests are great producers of raw material, on which rests an inverted pyramid of wealth in the form of both dollars and the intangible things like recreational and spiritual enjoyment, which pay for themselves fully in one form or another.

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[1] Allowable burn is the average annual burned acreage which it is estimated can be tolerated without defeating the full accomplishment of the resource management plans and objectives.

THE INDIAN FORESTS

By HENRY B. STEER, Senior Forest Economist, United States Forest Service

(Formerly Supervisor of Forests, United States Indian Service, Department of the Interior)

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HISTORICAL

Among the duties assigned to the War Department, when it was created by Congress under the act of August 7, 1789, were those "relative to Indian affairs."

The Office of the Commissioner of Indian Affairs was created in the War Department by the act of July 9, 1832. Subject to the Secretary of War and the President, the Commissioner was to have "the direction and management of all Indian affairs and all matters arising out of Indian relations." Two years later, on June 30, 1834, an act was passed "to provide for the organization of the Department of Indian Affairs." Certain agencies were established, others abolished. This act, considered the organic law of the Indian Department, provided for subagents, interpreters, and other employees, the payment of annuities, the purchase and distribution of supplies, etc.

The Bureau of Indian Affairs passed from military to civil control when the Department of the Interior was created by the act of March 3, 1849. Under section 441 of the Revised Statutes—

> The Secretary of the Interior is charged with the supervision of public business relating to * * * the Indians;

and section 463 provides that—

> The Commissioner of Indian Affairs shall, under the direction of the Secretary of the Interior and agreeable to such regulations as the President may prescribe, have the management of all Indian affairs and of all matters arising out of Indian relations (*1*, p. 1).[1]

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[1] Italic figures in parentheses refer to literature cited, p. 632.

Thus the Bureau of Indian Affairs has had the custody and management of Indian matters for over 100 years.

From the date of discovery of this country, when, nominally at least, the Indians were in possession of all the land, certain Indian rights of occupancy have been recognized, and it has been customary from the earliest days to secure at least a color of title from the Indians by the payment of a relatively small sum for the land that was acquired from the natives. A Federal act of 1790 (1 Stat.L.137) provided that no sale of land by an Indian or a tribe to any person or persons or to any State should be valid unless made under the provisions of a Federal treaty with the tribe. Under authority of this act the Federal Government continued to make treaties with the Indians for the cession of lands as if they were separate nations (*2*, p. 1041). Lands reserved to the Indians by these treaties came to be known as "Treaty reservations." This policy was discontinued in 1871, when by act of March 3 (16 Stat.L.566) the Congress declared that thereafter no treaties should be made with Indian tribes. By this act the Congress asserted its plenary power to legislate with respect to Indian affairs and to make whatever disposition of Indian lands appeared necessary or advisable. This power, even to the extent of abrogating a treaty, has been fully sustained by the Supreme Court. Under authority of this act, the lands which have been set aside for the use and occupancy of the various Indian bands and tribes by Executive orders have come to be known as "Executive order reservations."

Under various enabling acts, many allotments to individual Indians or additions to existing reservations have been made from the unappropriated public domain and many thousands of acres of land have been purchased for tribal or individual Indian use. Thus the four sources of Indian lands now under the jurisdiction of the Bureau of Indian Affairs are in order of their importance, as follows:

1. Treaty reservations.
2. Executive order reservations.
3. Additions to reservations by—
    (*a*) Purchase.
    (*b*) Executive order from public domain.
    (*c*) Executive order from national forests, and other national reservations.
4. Individual allotments—
    (*a*) From unappropriated public domain.
    (*b*) By purchase.

The various Indian reservations originally contained, as many of them still do, a great deal of fine timber. As has been the case with other forms of Indian property, the amount of interest, both official and general, evidenced in Indian timber has kept pace with the economic value of this Indian property. Generally speaking, Indian reservations were made in what was then relatively inaccessible country, and the exploitation of Indian timber resources, whether irregular and illegal in the early days as has been alleged, or under the supervision of the Federal Government in more recent times, has grown with the general economic development of those regions in which Indian reservations with important timber resources were located. Thus, from 1789 when the "Indian problem" was first officially recognized until the early 1880's, no great amount of attention was paid to the question of the actual ownership or management of the timber on Indian reservations. It was an early policy of the Indian Service, however, to permit Indians to remove timber from reservations for sale.

> Due to the actual need of the Indians and of their still more urgent imaginary need for funds, and in view of the pecuniary interest of the lumbermen and their agents in the acquirement of logs or stumpage from Indian lands, it may be conceded that not all the proceedings were strictly regular and ethical (*2*, p. 1042).

During this period the Indian timberlands were probably subject to much less illegal pilfering than were the timber resources of the entire Nation which were contained within the great area of unsettled, unpatented public lands. Although many complaints of timber stealing from public and Indian lands had been made in the early part of the nineteenth century it was not until the late 1860's that reports of reservation timber looting became numerous. Additional complaints during the next 20 years aroused public interest in this phase of the problem of Indian affairs, sufficiently to stir up a congressional investigation of Indian timberlands in the Lake States in March 1888 (*3*, p. 228).

For many years there had been a difference of opinion as to whether or not the property rights vested in the Indians for reservations established by treaties or Executive orders included standing timber. As late as 1873 it was declared by the highest court that the Indians had only a bare right of occupancy in their lands, and in 1888 and 1890 two successive Attorneys General of the United States held that the proceeds derived from timber cut in trepass from lands held in common by Indians under the ordinary Indian title belonged to the United States and not to the Indians of the band occupying the reservation (*2*, p. 1042). These decisions were greatly at variance with the then existing policy of the Indian Service, which allowed Indians to remove timber for sale. This difference of opinion, the complaints of irregularities in Indian timber matters, and the growing consciousness or awakening of the entire Nation to the general timber problem, were all factors in bringing the timber resources of the Indians before the public, and for the enactment of legislation looking to the proper management of these resources. Although the question of property rights in timber has been definitely settled by Supreme Court decisions, many people still think of and discuss Indian timber resources as if they were public property.

By an act of February 16, 1889 (25 Stat.L., 673) the Congress authorized the cutting of dead timber from any Indian reservation for sale, providing the President was satisfied there was no evidence that the timber had been intentionally burned. Several other acts pertaining to specific reservations (*3*, p. 230) were passed from 1889 on, which are interesting mainly because they were instrumental in setting up governmental machinery to dispose of Indian timber and mark the beginning of forestry work in the Indian Service, in that they provide for "the scientific and businesslike disposal of the Indian pine lands and the full protection of the rights of the Indian in connection therewith."

No act of general application other than the "dead and down" act of February 16, 1889, was passed until the act of June 25, 1910 (36 Stat.L., 857) which authorized the sale of mature timber from allotted lands anywhere within the United States and from tribal lands of any reservation except those in the States of Minnesota and Wisconsin. This act provided that the proceeds derived from sales of timber from tribal lands should be used for the benefit of the Indians of the reservation from which the timber was sold.

Prior to the passage of this act no general policy for the management of the Indian forest property had been promulgated. Questions of forestry policies on the several reservations had been handled administratively on the basis of the merits and needs of individual cases, and in accordance with legislation concerning specific reservations. For a short period (January 1908 to July 1909) the administration of Indian timberlands was under the jurisdiction of the Forest Service of the Department of Agriculture, but this agreement was in effect for too short a time to have much bearing on the development of a forest policy on Indian lands. Prior to 1910 the main development and exploitation of the Indian forests had, for economic reasons, taken place in the Lake States. The more inaccessible reservations of the West had received comparatively little attention, for the economic development of the West had not yet reached the point where there was any strong demand for the timber on these reservations.

The act of 1910, however, clearly contemplated conservative management of Indian timberlands, providing as it did for departmental regulations, and necessitating the development of a staff of men to carry out the intent of the act.

The organization of the forestry branch of the Indian Service, as it is today, was begun early in 1910, the Indian Appropriation Act for the fiscal year 1910 having set aside $100,000.

> To enable the Commissioner of Indian Affairs, under the direction of the Secretary of the Interior, to make investigations on Indian reservations and take measures for the purpose of preserving living and growing timber, and removing dead timber, standing or fallen; to advise the Indians as to the proper care of forests, and to conduct such timber operations and sales of timber as may be deemed advisable and provided for by law.

Similar items in every Indian appropriation act subsequent to 1910 have made possible the building up of the Forestry Branch of the Indian Service.

EXTENT AND IMPORTANCE OF THE INDIAN FOREST RESOURCES

The fact that the net acreage of Indian land has increased in recent years is of interest. On June 30, 1929, there were approximately 71 million acres of lands held in trust for the Indians by the Government, of which 39 million acres had been allotted to individual Indians and 32 million acres was unallotted or tribal land (table 1). During the fiscal years ending June 30, 1930, and June 30, 1931, the area of Indian allotted lands increased by about 43,000 acres, owing to the excess of acreage of new allotments over acreage of allotted land sold and fee patented, and the area of unallotted land increased by about 181,000 acres, the excess of areas purchased and added by Executive orders over areas allotted; making a net increase of about 224,000 acres.

Approximately 9 million acres of Indian forest land are under the jurisdiction of the Forestry Branch of the Indian Service, but it is impossible to list these lands as allotted or unallotted.

There are approximately 40 millions of acres of grazing land on the Indian reservations that are of major importance from a grazing standpoint.

TABLE 1.—*Areas of Indian lands, by regions*

Region and State	Total area	Allotted lands	Unallotted lands [1]	Forest lands managed by Forestry Branch [2]	Grazing lands on large reservations [3]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Middle Atlantic: New York	87,677		87,677		
South:					
Florida	26,741		26,741		
North Carolina	63,211		63,211	56,000	
Oklahoma	19,184,863	19,145,906	38,957		
Total	19,274,815	19,145,906	128,909	56,000	
Central:					
Iowa	3,480		3,480	(4)	
Kansas	272,661	271,478	1,183		
Nebraska	360,057	352,652	7,405		
Total	636,198	624,130	12,068	(4)	
Lake:					
Michigan	273,702	273,547	155		
Minnesota	1,491,026	935,299	555,727	870,000	
North Dakota	2,194,010	2,192,903	1,107		462,768
Wisconsin	604,459	330,874	273,585	410,000	
Total	4,563,197	3,732,623	830,574	1,280,000	462,768
Rocky Mountain North:					
Idaho	677,206	619,847	57,359	58,675	428,896
Montana	6,529,436	5,759,301	770,135	1,249,986	5,325,062
Total	7,206,642	6,379,148	827,494	1,308,661	5,753,958
Rocky Mountain South:					
Arizona	20,463,020	172,868	20,290,152	1,454,000	20,617,068
Colorado	478,154	82,011	396,143	184,000	
Nevada	847,409	15,227	832,182	4,000	271,449
New Mexico	3,888,821	353,971	3,534,850	362,000	1,799,100
South Dakota	6,671,906	6,408,795	263,111	40,000	4,963,656
Utah	452,627	111,947	340,680	131,000	311,333
Wyoming	2,243,822	246,822	1,997,000	200,000	1,869,367
Total	35,045,759	7,391,641	27,654,118	2,375,000	29,831,973
Pacific Coast:					
California	595,171	99,840	495,331	253,000	
Oregon	1,742,938	619,063	1,123,875	1,464,000	1,551,963
Washington	1,991,818	1,136,917	854,901	1,910,037	2,168,897
Total	4,329,927	1,855,820	2,474,107	3,627,037	3,720,860
United States	71,144,215	39,129,268	32,014,947	[5] 8,646,698	39,769,559

[1] General data concerning Indian reservations. Office of Indian Affairs, October 1929, p. 21.

[2] From an extensive survey made by the Forest Service, 1931-32.

[3] From an unpublished report of an economic survey of the range resources and grazing activities on Indian reservations, by Lee Muck, July 1931.

[4] Less than 500.

[5] This figure does not include 6,772,000 acres of the noncommercial forest land, mostly of piñon-juniper type, in Arizona and New Mexico.

In national terms, the 71 million acres of Indian reservations amount to about 3.7 percent of the total land area of the United States; the 9 million acres of Indian forest lands constitute only 1.4 percent of all potential forest land; and the 40 million acres of grazing land on Indian reservations are only 5 percent of all range lands. However, because the majority of the Indian reservations are located in the central and western regions of the country, the importance of Indian forest and range lands is much greater when considered from a regional standpoint. The distribution of forest lands is shown in table 2. Similar detail for grazing lands is not available, but since these are mainly found on the larger reservations, the bulk of them is in Western States where the stock-raising industry is most actively engaged.

TABLE 2.—*Comparison of Indian forest lands and timber with totals for States and regions* [1]

Region and State	Forest land			Saw-timber stand		
	All land	Indian reservations		All timber	Indian reservations	
	M acres	*M acres*	*Percent*	*Million ft.b.m.*	*Million ft.b.m.*	*Percent*
Lake:						
North Dakota	545	----------	----------	53	----------	----------
Michigan	19, 500	----------	----------	16, 430	----------	----------
Minnesota	21, 127	870	4. 12	8, 580	115	1. 34
Wisconsin	16, 595	410	2. 47	10, 824	969	8. 95
Total	57, 767	1, 280	2. 22	35, 887	1, 084	3. 02
Central (West):						
Iowa	2, 358	(2)	----------	1, 107	(2)	----------
Missouri	17, 500	----------	----------	3, 689	----------	----------
Total	19, 858	(2)	----------	4, 796	(2)	----------
North Rocky Mountain:						
Idaho	22, 479	59	. 26	96, 592	63	. 07
Montana	20, 267	1, 250	6. 17	49, 796	2, 227	4. 47
Total	42, 746	1, 309	3. 06	146, 388	2, 290	1. 56
South Rocky Mountain:						
Arizona	19, 426	[3] 1, 454	7. 48	19, 827	5, 538	27. 93
Colorado	20, 116	184	. 91	47, 379	----------	----------
Nevada	10, 847	4	. 04	778	----------	----------
South Dakota	1, 875	40	2. 13	3, 208	48	1. 50
New Mexico	19, 729	[3] 362	1. 83	14, 389	534	3. 71
Utah	8, 383	131	1. 56	7, 791	10	. 13
Wyoming	6, 714	200	2. 98	32, 584	865	2. 65
Total	87, 090	2, 375	2. 73	125, 956	6, 995	5. 55
Pacific coast:						
California	27, 371	253	. 92	282, 460	2, 918	1. 03
Oregon	29, 956	1, 464	4. 89	437, 852	9, 130	2. 09
Washington	22, 215	1, 910	8. 60	321, 316	9, 294	2. 89
Total	79, 542	3, 627	4. 56	1, 041, 628	21, 342	2. 05

[1] Forest Service, data. Areas withdrawn from timber use, as in parks, not included.
[2] Less than 500.
[3] These figures do not include the acreage of noncommercial piñon-juniper type.

In certain lumber- and livestock-producing localities (subdivisions of the regions given in table 2), and on important protection watersheds, Indian timber, range lands, and protection forests constitute one of the major classes of ownership and play an important part in industry and protection.[2] For example: Of the commercial timber tributary to the Klamath Falls (Oreg.) lumber manufacturing district, 47 percent is privately owned, 31 percent is on national forests, and 22 percent is on the Klamath Indian Reservation.

Of the commercial timber tributary to the upper Columbia River (Okanogan, Ferry, and Stevens Counties in Washington), 33 percent is privately owned; 32 percent is on Indian reservations; 25 percent on national forests; and 10 percent on State lands.

In eastern Oregon, including the Klamath District, the cut of Indian timber is over 20 percent of the total annual cut.

Similar examples showing the regional importance of Indian protection forests and grazing lands could be given if space permitted. Although some of the Indian reservations do not have timber and grazing resources of great commercial importance, and the development of these resources will naturally be limited to local requirements; yet, in formulating a national or regional forest program of general application, the major commercial forest and grazing resources of the Indians, comprising as they do a considerable portion of the total regional potentialities, should be reckoned with and assigned to their proper place in the general scheme of things.

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[2] The following examples are taken from an unpublished report (1931) by Lee Muck on the status of Indian forests in relation to a national program of sustained yield.

TIMBER

Indian forest lands support various kinds of timber, including the Appalachian hardwoods of North Carolina; the pine, hemlock, and hardwoods of the Lake States; the pine-fir-larch of Montana and the Inland Empire; the fir-spruce-cedar of the North Pacific; the redwood-fir of California; and the pine types of Arizona.

Of the 16 Western States containing approximately 68½ million acres of Indian land (or about 96 percent of the total) (table 1) six States, the Dakotas, Nevada, Nebraska, Kansas, and Oklahoma, do not contain Indian-owned forests in sufficient quantities to be of commercial importance. The bulk of merchantable timber in Indian ownership is in the States of Washington, Arizona, Oregon, and Montana, and consists of stands of timber typical of these States.

Accurate statistics of the extent and character of these resources are not available. The Forestry Branch of the Indian Service estimates, however, that there remained on June 30, 1931, approximately 30 billion feet of merchantable Indian-owned timber with a value of approximately $100,000,000, and about 10 billion feet of unmerchantable timber. Although a large part of the merchantable timber stands on lands which have been allotted to individual Indians, large bodies of timber remain in tribal ownership on some reservations.

ANNUAL CUT AND POTENTIAL PRODUCTION OF TIMBER

Over 7½ billion feet of timber with a value of about $33,000,000 has been removed from Indian lands under the jurisdiction of the Forestry Branch of the Indian Service since 1910, as given by years in table 3. This total does not include approximately 2 billion feet of timber which was sold from lands of the ceded Chippewas in Minnesota under the supervision of the General Land Office, and sales of land and timber belonging to the Choctaw and Chickasaw tribes in Oklahoma for about $9,000,000.

TABLE 3.—*Timber cut from Indian lands* [1]

Year	Volume	Value	Year	Volume	Value
	M ft. b.m.	*Dollars*		*M ft. b.m.*	*Dollars*
1910	141, 532	900, 612	1922	216, 583	808, 551
1911	137, 208	752, 303	1923	493, 563	1, 856, 323
1912	123, 472	739, 699	1924	510, 314	1, 937, 245
1913	170, 766	1, 028, 184	1925	467, 779	1, 921, 157
1914	143, 426	780, 856	1926	579, 958	2, 446, 455
1915	138, 624	773, 483	1927	627, 365	2, 953, 752
1916	167, 602	726, 483	1928	639, 244	2, 676, 779
1917	205, 312	715, 453	1929	660, 257	2, 818, 317
1918	323, 131	1, 253, 651	1930	561, 415	2, 313, 644
1919	291, 164	1, 303, 840	1931	314, 528	1, 238, 814
1920	398, 485	1, 585, 812			
1921	348, 300	1, 390, 436	Total	7, 660, 028	32, 921, 849

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[1] Under jurisdiction of Forestry Branch.

Detailed possibilities of the potentialities of Indian forest lands for the production of tree crops are not available. The following general conclusions, however, are self-evident, and represent the best judgment of those familiar with Indian forest resources:

(*a*) Indian timber is being harvested faster than it is being replaced by growth.

(*b*) The amount cut annually may be subject to some fluctuation in the immediate future, but must inevitably decline from the most recent 5-year average.

MANAGEMENT OF INDIAN FORESTS

LAND AND ALLOTMENT POLICY

The general policies of the Indian Service since its organization have been subject to more or less change due both to administrative judgment and to the changing nature of the Indian problem itself. Since the problem of handling Indian forests is but one phase of the Indian question, forest policies cannot determine general policies. On the contrary, the exact opposite is true. The uncertain status of Indian lands is the crux of the present unsatisfactory situation. Not only is there no assurance that areas of Indian forest land now held in tribal ownership will have that status a decade from now, but the probability is that, in view of decisions of the Supreme Court, many thousands of acres of heavily timbered tribal land which is mainly, if not entirely, valuable for the growth of timber will be allotted to individual Indians.

The land policy of the Indian Service is and has been dependent almost in its entirety upon the then existing policy as to how Indian land was to be held in ownership, and especially with regard to the removal of measures originally designed to restrict the assumption of the Indian of the responsibility of property ownership and the extent to which he was able to forego his ancient method of living and assume economic independence in direct competition with the whites.

Originally all Indian lands, whether reserved by treaties or set aside by Executive orders, were held in common by the several tribes. Relatively early in the history of the Indian Service many allotments of land to individual Indians were made in fee, with a restriction on alienation, except with the consent of the Secretary of the Interior. Later on, under authority of the General Allotment Act of 1887, known as the Dawes Act, and numerous later acts of general scope or which pertained to specific reservations, many millions of acres of land have been assigned to individual Indians. Allotment acts have generally provided that the United States would hold the lands in trust for the allottee for a period of 25 years from the date of allotment, and at the end of that time would convey the land to the allottee or his heirs "in fee, discharged of such trust and free of all charge or incumbrance whatsoever." Trust periods have in many cases been extended, and many thousands of fee patents have been issued before the expiration of the trust period.

The primary purpose of the allotment (*2*, p. 1045) is theoretically to provide a home for the Indian, and by encouraging and aiding him in achieving economic independence by the pursuit of agricultural and stock-raising activities dissolve the tribal relationship and thus solve the Indian problem. There can be no doubt, in view of the general objective sought in the allotting of land to individual Indians, that the original intention was to allot only agricultural land. By implication the General Allotment Act of 1887 did not include timberland. However, upon reservations where there was an insufficiency of agricultural land to supply all members of the tribe with allotments, where the better agricultural land was covered with timber, where practically all the land was forested, or where the allotment was made under special acts, timberlands have been allotted. In addition to this, decisions of the courts (unfortunate from the standpoint of timber conservation and sustained yield forest management) have forced the allotting of many thousands of acres of timberland to individual Indians. A notable example is the Quinaielt Reservation in Washington. Recent legislation has been passed (act of May 21, 1928), authorizing the allotment of grazing lands on the Shoshone Reservation in Wyoming from which no Indian (or white) can wrest a living.

Individual Indian allotments soon pass out of governmental control in either of two ways:

1. By the issuance of fee patents or certificates of competency to the allottees or their heirs, permitting their sale by the individual.

> The records show that the lands of a vast majority of Indians who have been given absolute control of their allotments have passed from Indian ownership in various ways—by sale for small values, through unredeemed mortgages, and in some instances by tax deeds (*13*, p. 10).

2. Through outright sales, made to private individuals or corporations by the Government for and in behalf of the allottees or their heirs. The heirship of an Indian allotment frequently becomes so badly involved that the shares of each heir are of small value and the tangled records can best be cleared by an outright sale of the land.

The policy of the Indian Service with regard to the issuance of fee patents and certificates of competency, and the sale of allotments has varied greatly since 1900 and has had a marked effect on the formulation and carrying out of forest policies on these lands. Under provisions of the acts of May 8, 1906 (34 Stat.L., 182) and June 25, 1910 (36 Stat.L., 855) fee patents were issued under a rather conservative policy, until about 1916, when "competency commissions" were appointed which recommended the issuance of fee patents to large numbers of "competent" Indians.

In 1920, the Commissioner (*14*, p. 49) reported:

> Since the Declaration of Policy in 1917 (patents in fee issued to Indians of one half or less Indian blood without any further proof of competency), 17,176 fee patents have been issued which is nearly double the number issued in the 10 years preceding.

The rather liberal policy followed from 1915 to 1920 with regard to the issuance of fee patents was made more conservative in 1921. In 1922 the Commissioner stated (*15*, p. 15):

> A stricter policy has been followed in issuing patents to Indians on the ground of competency, as seemed to be required in order to more fully protect their interests.

In his report for the fiscal year 1926, the Commissioner stated (*13*, p. 10):

> For the past 5 years a conservative policy has been pursued in granting fee titles to individual Indians * * *.

In 1927, the Secretary of the Interior recorded (*8*, p. 12) a still further back swing of the pendulum:

> * * * The act of February 26, 1927, which authorized the cancelation of patents in fee issued without application for or consent of the patentee in cases where the land has been neither encumbered nor sold. Pursuant to this legislation and to decisions of the Federal court, a number of patents heretofore issued were canceled.

It is interesting to note that the acreage of Indian allotments fee-patented in those years for which data are available varied from over 1,400,000 acres in 1920 to about 30,000 in 1931.

Meriam and associates stated in 1928 (*9*, p. 40) that:

> All land which has been or will be allotted to individual Indians must become inherited land in a relatively short space of time, and will pass from Indian ownership, as millions of acres have already done.
>
> The problem of inherited land should be given thorough detailed study * * *. It is doubtful if the serious nature of this problem was appreciated at the time the allotment acts were passed. Because of this feature of the allotment system the land of the Indians is rapidly passing into the hands of the whites, and a generation of landless, almost penniless, unadjusted Indians is coming on. What happens is this: The Indian to whom the land was allotted dies leaving several heirs. Actual division of the land among them is impracticable. The estate is either leased or sold to whites and the proceeds are divided among the heirs and are used for living expenses. So long as one member of the family of heirs has land the family is not landless or homeless, but as time goes on the last of the original allottees will die and the public will have the landless, unadjusted Indians on its hands.

This condition is already well advanced in some instances, such as the Chehalis, Nisqually, and Skokomish Indians of Washington.

Meriam and associates also state (*9*, p. 41) that:

> The policy of individual allotment has largely failed in the accomplishment of what was expected of it. It has resulted in much loss of land and an enormous increase in the details of administration without a compensating advance in the economic ability of the Indian.

As to what has happened to allotments which have been fee-patented, the annual report of the Commissioner of Indian Affairs for the fiscal year 1921 (*16*, p. 25) contains this very interesting statement:

> As is well known, the law provides for issuing to the Indian a trust patent upon the land allotted to him, which exempts it from taxation and restricts him from its sale or encumbrance until he is declared competent to manage his business affairs, when he may, upon application, receive a patent in fee and be free to handle or dispose of his land the same as any white citizen.
>
> It is doubtful if a satisfactory method has been found for determining the competency upon which to base a termination of the trust title. Applications for patents in fee have too often been adroitly supported by influences which sought to hasten the taxable status of the property or to accomplish a purchase at much less than its fair value, or from some other motive foreign to the Indian's ability to protect his property rights.
>
> Notwithstanding the sincere efforts of officials and competency commissions to reach a safe conclusion as to the ability of an Indian to manage prudently his business and landed interests, experience shows that more than two thirds of the Indians who have received patents in fee have been unable or unwilling to cope with the business acumen coupled with the selfishness and greed of the more competent whites, and in many instances have lost every acre they had.

Thus the net result of continued allotting of land to individual Indians will result in continued loss of land to the Indians with no real compensating economic gain, and "the public will have the landless unadjusted Indians on its hands." This applies particularly to forest and range land.

> Many Americans entertain the very erroneous view that the individuals in every tribe or band of Indians, to whom allotments have been made, have received all that they need to enable them to achieve economic independence. This view is based upon egregious misunderstanding of the facts. There are hundreds, possibly thousands, of instances (greatly increased since this article was written) in which Indians have been given allotments of 80 or 160 acres upon which it is utterly impossible for an Indian, or a white man, to make a livelihood. Such individuals must on many reservations rely upon the privilege of grazing stock on tribal land to obtain a living (*12*, p. 619).

On many reservations relatively large areas of forest and range lands remain which if retained in tribal ownership and conservatively managed will not only be a source of uninterrupted revenue to the Indians but will continue to play an important and essential part in the economic life of the Indians by their use of tribal grazing, hunting, and fishing resources. On many reservations Indians have already lost their allotments, have not been assimilated, and are dependent on tribal lands of their own tribe or that of other tribes for a place to live.

The breakdown of unified ownership of tribal lands has not only been accomplished through the making of allotments but has been furthered by the throwing open to homestead entry by whites of hundreds of thousands of acres of so-called "agricultural land" not infrequently covered with timber, on which the white settlers have been unable to make a living and which they have abandoned. To the substantiation of this fact hundreds of abandoned shacks and fairly well constructed houses now scattered over the Flathead (Montana) and Colville (Washington) Reservations give mute but impressive testimony.

The checkerboard ownership of forest lands on Indian reservations which has resulted from the above and the knowledge that this condition is apt to become worse in the future are responsible for what is perhaps the most difficult problem of forest and range administration on Indian lands. Indeed the damage done must not only be corrected insofar as is practicable, but if the proper management of Indian forest and range lands, both from the standpoint of the Indian owners and the general public, is to be made possible, prompt action must be taken to prevent like occurrences on reservations where large areas of forest land remain in tribal ownership.

The time when the American Indians as a race will have acquired a sufficient amount of general economic background, knowledge, and ability to enable them to live successfully in a white man's world without governmental aid has certainly not arrived yet. When it will arrive is a matter of opinion and will depend in a large measure upon how thoroughly and promptly the United States discharges its all-too-evident duty to these people. Meriam and associates, after a thorough investigation of the Indian problem (*9*, p. 746), ventured this statement:

> The survey staff found no evidence that warrants a conclusion that the Government of the United States can at any time in the near future relinquish its guardianship over the property of restricted Indians secured to the Indians by Government action. Although the staff believes in the transfer of the activities relating to the promotion of health, education, and social and economic advancement of the Indians to the several States as rapidly as the States are ready effectively to perform these tasks, it is of the opinion that the guardianship of property should be the last duty thus transferred if it is transferred at all.

PECULIAR ASPECTS OF INDIAN PROBLEM

In considering the management of Indian forest lands, allowance must be made for certain aspects which are peculiar to the Indian problem.

Indian lands "are private property, held in sacred trust by the United States for the benefit of the Indians" (*5*, p. 841). The United States Indian Service was designated by the Congress more than 100 years ago as the Government bureau responsible for the custody and administration of Indian property, and this property has been and is now handled by the Indian Service in accordance with provisions of laws enacted by the Congress and interpreted by the courts. Under these laws and interpretations the Indians are entitled to enjoy the full benefit to be derived from forests and other natural resources on their lands. Indian forests are owned by Indians and managed primarily for the best benefit of their Indian owners, and Indian forest policies and Indian forestry activities cannot be determined and carried on solely from the standpoint of technically correct forest working or management plans, nor with the forest needs of the entire body politic primarily in view.

Furthermore, forestry on Indian lands is inevitably tied up with the general Indian problem, a complex puzzle not yet solved and necessitating the consideration of many questions connected with the educational, social, and industrial welfare of this race. The administration of Indian forest-property interests is inseparably intertwined with other phases of Indian administration (*5*, p. 842), and it has sometimes been necessary to adopt Indian forest policies widely divergent from theoretically correct forest-management policies because of the needs of the Indian owners. Indian forest policies must be varied and modified to fit social and economic conditions on the several reservations and even on different parts of the same reservation.

On some reservations the merchantable stand of timber on tribal lands constitutes practically the only source of revenue from which the cost of social and industrial betterments for the tribe can be met by the Indian Service. Hundreds, nay, even thousands, of destitute Indians have been allotted tracts of heavily timbered land. The only means the Indian Service has had through which to keep these unfortunate people from starvation is to sell their timber and derive therefrom as large a revenue as possible. Other recipients of heavily timbered allotments have needed money for educational purposes, for the building of houses, or for the purchase of farming equipment (*6*, p. 473). Under such circumstances, insistence upon the practice of a highly intensive forest policy cannot be justified. Such conditions demand flexibility not only in formulating general policies but in carrying them out.

Under the peculiar conditions which surround and govern the administration of Indian affairs, the permanency of Indian forest policies can be no greater than the permanency of general Indian Service policies which are based on legislation enacted by the Congress, interpreted by the courts, and carried out under regulations promulgated or approved by the Secretary of the Interior. Under decisions of the Supreme Court of the United States the status of Indian lands may be modified at any time by an act of Congress. Furthermore, there have been court decisions holding that lands which the Indian Service considers primarily valuable for the production of timber crops may be selected by individual Indians for allotment purposes and thus become subject to private ownership irrespective of any policy or purpose of the Interior Department to hold such lands for timber production (or protection) purposes (*7*, p. 430).

The science of forestry, or at least that most fundamental phase of forestry dealing with the production and management of forest crops, is unavoidably a long-time proposition. Reasonable assurance as to the stability of land ownership of areas to be put under a scientifically evolved forest-management plan must be given before the postponement of some revenue from timber capital (under selective logging) and the expenditure of money for permanent improvements, reforestation, afforestation, and in some cases fire protection, can be justified.

These facts have long been recognized by those responsible for the management of the forest properties of the Indians, and must occupy the foreground of any picture of Indian forest policy or practice.

A further consideration that must be taken into account in any appraisal of the Indian forest problem is that the Indian Service as a whole, and the Forestry Branch in particular, has been undermanned and underfinanced since inception. The annual report of the Bureau of Indian Affairs for 1927 (*8*, p. 1) reads:

> The Indian Service has not kept pace with the progress elsewhere along health, educational, industrial, and social lines. The appropriations for general purposes for the fiscal year 1923 were $10,316,221.30, and in the 5 fiscal years since they have been increased by about $2,338,463.70, principally for medical and health activities. But the cumulative effect of many years of financial neglect has demanded even larger appropriations, if the Government may perform its full duty to the American Indian. Underrating the requirements of the Indian Service has continued so long that it has become a habit difficult to correct.

In considering what has been accomplished in forestry activities on Indian lands in the last 22 years, the fact that the Forestry Branch of the Indian Service has never had sufficient funds for needed personnel, equipment, fire prevention and suppression, timber sale administration, and all other kinds of forestry work, must be fully recognized. Although a complete record of the quantity of timber involved and proceeds derived from timber sales from Indian lands has been kept, accurate statistics of other activities of the Forestry Branch of the Indian Service and of the forest properties under its supervision are, generally speaking, not available, solely because, with the limited authorized personnel and funds available, it has not been possible to compile data of this character.

Finally, the public attitude toward Indian lands must be considered to have had a very considerable influence on management policies. With but few exceptions, interest of the general public in the Indians has kept pace with the appreciation in value of Indian property. To quote (*7*, p. 431):

> Just as land-hungry adventurers sought homestead and mining claims within national forests (mainly between 1905 and 1918), so did they surge about the borders of Indian reservations whetting their land appetities on various morsels of misinformation with respect to the fortunes lying dormant—yea, indeed locked up—within the illogical and arbitrary boundaries of Indian reservations.

It is a sad commentary on human nature, but a fact nevertheless, that a large amount of the interest of the public in general and the big majority of public organizations and individuals in Indian affairs and property has been caused by cupidity. The result of the application of intense local and national political pressure has created serious questions in the actual management of Indian forest property.

GENERAL FOREST POLICY

The general policy of the Forestry Branch of the Indian Service may be quoted as follows (7, p. 434):

> A. To administer all allotted timber lands so as to insure the highest present economic return consistent with a reasonable consideration of the future use to which the land will probably be devoted.
>
> B. To administer all tribal lands that are primarily adapted to the production of timber, or the protection of slopes, in such manner as to secure the highest present economic return for the tribe that is consistent with theoretically correct forestry principles and to preserve these lands so that whether they remain permanently as communal lands of a tribe, are acquired by the Federal or State Government, or are sold in large areas to private interests, they shall remain productive and capable of doing their part toward insuring the future welfare of the citizens of the United States of which the Indians themselves are a part.

All sales of Indian timber made under authority of the act of Congress of June 25, 1910, have clearly contemplated the cutting of the timber in such manner as to insure the maintenance of the forest cover on all lands primarily adapted to the production of timber crops.

In evolving and carrying out timber-sale plans the following points, given in order of importance, have been considered:

A. The financial need of the Indians, individually and collectively.

B. The potential and actual resources of the Indians and the extent to which it is necessary for them to liquidate their timber capital to provide funds for social, educational, industrial, and general economic betterments.

C. The demand for Indian stumpage.

D. The extent to which scientific forestry can be practiced in view of the above.

Timber-sale plans, in addition to the above, must be and have been varied to fit different silvicultural conditions obtaining on the several reservations and even on different parts of the same reservation. In fact, when other considerations (particularly economic) remain constant, timber-sale plans are almost entirely dependent upon what is desirable and feasible from a silvicultural standpoint.

J. P. Kinney states the situation (7, p. 433) in general terms thus:

> On many reservations a large part of the standing merchantable timber was mature or over-mature and the removal of all mature timber would leave little reproduction or advance growth. On areas of this character it has been the policy to leave a part of the mature timber for seed trees. Where there is a mixed stand of mature and immature trees of yellow pine, or mixed types, in the yellow-pine region, a true selective cutting has been made. In the Douglas fir, cedar, spruce, and hemlock type of western Washington we have generally followed the policy of cutting all mature trees and, as all who are familiar with these coast types know, very few trees of any species remain uninjured when the logging is completed.
>
> * * * The conditions are quite variable on reservations both in the Northwest and the Southwest. On the Colville in Washington fairly satisfactory reproduction conditions exist which are coupled with most extreme fire danger; on the adjoining Spokane fully as good reproduction factors are found with materially lower fire risk and with a much larger percentage of the timber land included within allotments; on a large part of the Klamath there is little reproduction or advance growth associated with over-mature stands, and on the Flathead the saw timber has been reserved for the tribe on tens of thousands of acres for which individual Indians have been given trust patents. * * * On

the Mescalero and Fort Apache Reservations in the Southwest, where excellent conditions for western yellow pine reproduction and quite generally fair advance growth on tribal lands are found, the reserving of a fair stand of vigorous young or middle aged trees is justified; but on the Jicarilla where practically all timber land is allotted and the beneficial interest of the tribe in the timber will expire in 1932, the removal of the greater part of the mature timber is clearly indicated.

SILVICULTURAL PRACTICE

The forestry branch of the Indian Service is now guided, and has been for some years, by broad conservative forest policies which may be summarized as calling for the maximum returns from Indian forest resources consistent with sound silviculture. Although the silvicultural practice followed on the various reservations has been made to fit local forest conditions wherever possible, the utter impossibility of accomplishing very much silviculturally as long as land tenure is most uncertain is obvious. In spite of this obstacle of uncertain land tenure Indian Service foresters have been guided in the development of silvicultural practice by the probable future use of lands now forested as well as by the necessity of realizing the maximum returns to the Indians. Notwithstanding the peculiar difficulties involved, the development of silvicultural practice on Indian reservations has kept pace with the general development of this science on publicly managed lands and is far in advance of that obtaining on the vast majority of private lands. The results obtained on two reservations where the land tenure is less uncertain than on the average reservation, namely the Menominee in Wisconsin and the Klamath in Oregon, have been highly commended by foresters of national and international reputation.

In view of legislation and court decisions which have resulted in the allotting of much valuable timberlands to individual Indians, sustained yield cannot be successfully practiced on some Indian reservations until the property rights of individual Indians established by the courts have been taken care of. If tribal forests are to be established and put on a sustained yield basis, or if Indian forest areas in their present ownership are to be put on that basis, individual Indians must, in all equity, be compensated for the loss of income from their personal property. Any plan of sustained yield and unified ownership cannot, in justice to the Indian, be promulgated and legislated without acknowledging and fully satisfying the property rights of individual Indians. "Foresters should not sacrifice the well-established rights of men on the altar of speculative theory as to the rights of trees."

GRAZING RESOURCES AND ADMINISTRATION[3]

The scope of country embracing the important livestock-producing Indian reservations is very large and includes many variations in range conditions. Of the 40 millions of acres of grazing land in Indian reservations about 13 million acres is in the Great Plains region of the Dakotas, Montana, and Wyoming; 4 million acres in the Intermountain region of Idaho and eastern Washington and Oregon; and 23 million acres in the Southwestern States of Utah, Colorado, Arizona, and New Mexico. These large areas, conforming in general characteristics to those of the semiarid regions in which they are situated, are suited to the large-scale production of range livestock. The natural features of some reservations limit their economic possibilities to the development of this industry, and the crop of native forage is the most valuable product of a large area of Indian lands. In 1929, 1,396,776 head of stock owned by individual Indians, 51,411 head of tribally owned stock, and 946,069 head of permitted stock owned by whites obtain pasturage on Indian reservations and brought in a cash income of about $700,000.

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[3] Material presented under this heading has been taken, in part, from a report by Lee Muck, entitled "An Economic Survey of the Range Resources and Grazing Activities on Indian Reservations."

Immediately after the organization of a forestry unit in the Indian Service in 1910, attention was given to grazing conditions on reservations in the Southwest, and for 6 or 8 years supervision of grazing activities was maintained on several reservations. As efficient forest organizations were developed on timbered reservations in the Northwest, range control has been assumed on the Flathead, Colville, and Yakima Reservations (some 15 years ago), and more recently on the Klamath, Spokane, and Tongue River Reservations. With these exceptions, grazing matters on Indian lands have not been an activity of the Forestry Branch, but have been handled by the superintendents of the several reservations. On April 15, 1930, the Secretary of the Interior placed the supervision of all range activities on Indian lands in the forestry branch.

In the administration of Indian grazing resources, it has been the policy of the Indian Service, in accordance with existing regulations, which provide for season of use, number and class of stock, etc., to give preference to Indians owning herds. Excess grazing land not needed by Indians is then blocked out into units and adequately advertised, sealed bids are required, and the units are leased to the highest bidders. This policy brings to the Indian owners the greatest financial return from use by whites of their grazing resources.

The objectives of management and grazing policy have been summarized by Muck in the report already cited as follows:

> A. The preservation of land, water, forest, and forage in a safe and entire state; the utilization of these resources for the purpose to which they were dedicated by nature; and the full enjoyment thereof, today, without destroying the promise of continued enjoyment tomorrow.
>
> B. The permanent welfare of the livestock industry, generally, and the Indian livestock industry in particular, through proper care and improvement of grazing lands, under principles conforming to the requirements of practical operations.
>
> C. The protection of the interests of the whole Indian people against unfair competition, the inequable utilization or distribution of forage values and the exploitation of communal and individual assets of the open range by the more aggressive individuals.
>
> D. The conservative utilization of all forage resources, primarily through the development of the livestock industry among the Indians and secondarily, through the regulated sale of grazing privileges to the end that economic waste will be largely, if not wholly, eliminated and a balanced net income realized for the permanent benefit of the majority of the Indians.

The management policy contemplates the systematic regulation of Indian grazing resources by—

(*a*) Increase in the number of stock on undergrazed lands.

(*b*) Readjustment of existing ranges by carrying out carefully evolved and scientific grazing management plans to obtain the maximum amount of revenue consistent with sound practice.

(*c*) The reduction of the number of stock on the overgrazed reservations of the Southwest.

Existing regulations specify that where sufficient tribal lands are available, an Indian family may be permitted to graze not to exceed

50 horses, 100 cattle, or 500 sheep or a combined equivalent thereof in the several classes enumerated. This regulation has been sustained by Federal court opinion and has been rigidly enforced in both the northern Great Plains region and the Intermountain region. However, it has been violated and more or less consistently ignored in the Southwest region (*10*, p. 12, 300) where for decades these Indians have secured their main living from sheep and goats. The rehabilitation and revegetation of these overgrazed lands, without arousing the animosity and the violent opposition of those who obtain their precarious living from these ranges, is regarded as "a problem to tax the ingenuity and skill of any forester" (*2*, p. 1052).

Accurate data concerning the potential revenue which can be realized from Indian grazing lands are not available. It is probable, however, that, under scientific management, receipts in the future from grazing permits will not be less than the amount received in 1931. On the contrary with the return of normal economic conditions, the systematic use of available resources, and the discontinuance of certain unwise practices, such as the use of valuable range lands by large numbers of worthless Indian ponies, a substantial increase in revenue may be made.

Immediately after the supervision of range activities was given to the Forestry Branch an economic survey of the range resources and grazing activities on Indian reservations was undertaken. Shortly after the completion of this survey corrective measures were initiated and considerable progress has been made in systematizing and improving the management of this important Indian resource, although the usual handicaps of insufficient funds and personnel exist.

WATERSHED PROTECTION AND WATER CONSERVATION

It is not possible to give accurate statistical data concerning the importance of Indian forest lands for the protection of watersheds and for water-conservation purposes. Forests on many thousands of acres of Indian land may, however, properly be classified as protection forests, for very frequently the headwaters of streams of immense importance in irrigation projects are located within Indian reservations.

The policy of the Indian Service both with regard to forest and range lands is to administer these lands with their protective importance clearly in mind and to insure the maintenance of an adequate ground and tree cover. If, however, these lands are to receive the protection which their importance warrants, the uncertain tenure of ownership must be removed and the Indian Service given an increased personnel and more funds for protection purposes.

WILD LIFE

The majority of Indian reservations in the Western States are situated in the more inaccessible regions, and as a result of this remoteness and because on practically all reservations where Indians have been accustomed for generations to rely on game and fish for food, the right to hunt and fish regardless of season has been reserved for them in treaties.

Indian reservations as a rule are better stocked with wild life and fish than are adjacent lands. Also, the Indian, generally speaking, does not hunt or fish for sport but for food, and will not take more than is needed for that purpose.

Indians do not take kindly to the abrogation of hunting and fishing practices which are as old as the race itself. However, as they adapt themselves to the white man's methods of living their reliance on wild life for food supplies diminishes.

Whereas, not so many years ago, the Indian tribes were accustomed to hunt and fish on large areas of land; in recent years, due to the restriction and development of adjacent land, they have been confined to their reservations. Because of the restriction of hunting and fishing by Indians to their reservations, the supplies of game and fish have been reduced in recent years. While some streams have been stocked with fish, there is urgent need for the restriction of hunting and fishing out of season, and it will be necessary, if Indian streams and forests are to produce fish and game to potential capacity, to do a considerable amount of restocking streams with fish and woods with game.

The importance of the wild-life resources of Indian lands to the Indians varies with the degree that Indian tribes have departed from ancient modes of living and methods of obtaining food supplies, and they should be managed accordingly.

The policy of the Indian Service in this matter may be stated as follows:

1. Conservation of these resources by education and encouragement of the Indians in wise use.
2. Cooperation with State and Federal authorities and conformity with State and Federal laws and regulations whenever such conformity is possible under existing Indian treaties and would not deprive the Indians of an important source of food supply.

RECREATIONAL POSSIBILITIES

Development of the recreational possibilities of Indian reservations must always give primary consideration to the Indians. These possibilities are many, for Indian reservations include a great variety of lands not only of scenic and inspirational value on which all forms of outdoor sport and recreation may be enjoyed, but have an unusual attraction for many thousand vacationists annually because of the Indian himself and the history of his race.

The development of the recreational possibilities of Indian reservations for the benefit of whites cannot properly be undertaken by the Indian Service through the use of Indian tribal moneys. Specific gratuity appropriations would be needed for this work. The problem of management has been summed up by Kinney (11) thus:

> The full realization of these possibilities may be achieved only through sincere and effective cooperation between the Indian Service, the Indians themselves, and those representatives of the general citizenry of the Nation who are able and willing to ascertain the true facts and ready to lend their support to all efforts toward a solution of the intricate problem of properly integrating the Indian lands and the Indian character with the national resources, physical, mental. and moral.

OTHER USES OF INDIAN FORESTS BY INDIANS

Indian forests have played and should continue to play an important part in the economic life of their owners by the use of Indian owned and operated sawmills of two general classes:

(*a*) Small mills operated mainly to produce lumber and other building materials for Indian buildings, and (*b*) Mills designed to manufacture lumber and other products for sale in commercial markets, as well as for Indian use.

As Indian labor is usually less efficient than white labor, and because small mills (with a daily output of 2,000 to 20,000 board feet) can be operated for only short periods, the commercial operation of Indian mills is difficult and has not been attempted in most instances. They are operated mainly to afford the Indians a means of industrial training and to act as an incentive in the improvement of housing conditions on the reservations, and their maintenance must be justified on educational and social grounds rather than economic. Accurate yearly statistics concerning these mills are not available. The number in operation has varied from 30 in 1911 to 25 in 1931. Besides paying the Indians a substantial amount of wages, these mills have exerted no little influence in industrial and social betterments on some reservations.

There are at present two sawmills (and logging operations) in Indian timber which are operated commercially by Indians under the supervision of the Forestry Branch, namely, on the Red Lake (Minn.) and Menominee (Wis.) Indian Reservations.

The Red Lake operation dates from 1925, has an output of approxmately 5 million board feet per year, and (up to Apr. 1, 1930) paid the Indians over $300,000 in wages and accumulated a stumpage credit of over $250,000. The Menominee operation, started soon after the passage of the act of March 28, 1908 (35 Stat. L., 51), has earned (up to December 1930) a net income of over $3,700,000 (stumpage and net operating profit) besides paying millions of dollars in wages to Indians. Meriam and associates in "The Problem of Indian Administration," Institute for Government Research, 1928, said (p. 516) concerning the Menominee operation:

> At the Menominee Reservation Indians are employed both in the camps and in the mill. One got the impression that the Indians there were doing more work and prospering more than was the case on other reservations, and for this situation the policy of employing Indians in the timber and mill operation was apparently largely responsible. Interviews with the white officers on this reservation brought out the opinion that the policy of employing Indians increased the cost of production, that if a private commercial company had charge of the operations they could reduce labor costs by employing a smaller force made up almost entirely of white men. The tendency is to give the Indian who applies for work a job, whether he is actually needed at the moment or not, because the welfare of the Indians is placed ahead of the immediate interests of the balance sheet. At times Indians have occupied some of the more responsible positions requiring skill and experience, although it may be doubted whether they could have held these positions in a commercial mill where they would have been in direct competition with the whites. Despite this policy of preferring Indians, the available statistics indicate that the operations are carried on at a profit.
>
> The survey staff has not made a detailed examination of the accounts of the Menominee operations, but it is of the opinion that even if the profits are not what they might be with a white staff, the undertaking is well worth while because of the training and economic opportunities it affords the Indians. It is not only a commercial enterprise, it is also educational. The superintendent at the time of the survey visit showed a keen appreciation of the social side of his task.

The number of Indians engaged in work with timber other than at Red Lake and Menominee is small. It has been stated on numerous occasions, however, that the advisability of initiating other tribal enterprises such as are now being carried on at Red Lake and Menominee should be carefully considered.

In addition to the above many thousands of Indians are dependent upon Indian timber for their fuel supply.

FOREST-FIRE PREVENTION AND SUPPRESSION

One of the most important duties of the Forestry Branch of the Indian Service is the protection of at least 9 millions of acres of Indian forest lands from fire. Many Indian reservations contain large areas of timberlands which are relatively inaccessible and undeveloped, making fire suppression exceedingly difficult and expensive. Although appropriations for this purpose have been somewhat increased in recent years, sufficient funds for equipment, improvements, and personnel to protect Indian forest land from fire adequately have not, generally speaking, been available. The Indian Service has, however, made considerable progress in this work. Since 1910, 43 lookout stations have been built, and over 4,500 miles of road, over 900 miles of trail, and about 2,500 miles of telephone line have been constructed which are principally of value for fire protection and suppression purposes (table 4).

Accurate statistics as to the causes and extent of forest fires, the resultant damage, and the costs of suppression of such fires on Indian reservations are not available over a long period of time. Table 5 presents the best record obtainable, based on reports submitted by superintendents and forest officers. It is probably somewhat in error, especially in the early years, in that some grass and open fires may have been included.

TABLE 4.—*Roads, trails, telephone lines, and lookouts on reservations of major importance from a forestry standpoint*

Reservation	Gross area	Lookouts	Roads	Trails	Telephone lines
Arizona:	*Acres*	*Number*	*Miles*	*Miles*	*Miles*
Fort Apache	1, 664, 872	5	445		320
Northern Navajo	3, 084, 200		117		21
San Carlos	1, 610, 240	1	25		46
Southern Navajo	3, 775, 765	1	450		191
Western Navajo	3, 500, 000		556		169
California: Hoopa Valley	116, 064		11	20	26
Idaho:					
Coeur d'Alene	63, 881				2½
Fort Hall	492, 564		30		
Minnesota:					
Consolidated Chippewa	59, 270	3	32		20
Red Lake	543, 528	4	50		57
Montana:					
Blackfeet	1, 492, 042	1	8		42
Flathead	1, 240, 000	1	[1] 200		183
Rocky Boy	55, 040		22		15
Tongue River	442, 960	2	31		66
New Mexico:					
Jicarilla	743, 220	2	300		104
Mescalero	474, 240	1		300	114
Santa Clara	30, 360	1	5		3
North Carolina: Cherokee	63, 820	1			8
Oregon:					
Klamath	1, 107, 336	3	1, 040		366
Warm Springs	463, 669	1	287		135
Washington:					
Colville	1, 385, 086	6	409	488	305
Neah Bay	26, 952				
Quinaielt	189, 621	2	12		29
Spokane	148, 635	1	128	11	73
Tulalip	22, 500		6		7
Yakima	1, 182, 030	4	237	6	174
Wisconsin:					
Lac du Flambeau	52, 491		90		8
Menominee	230, 400	3	90		69
Wyoming: Shoshone	800, 000		35	80	
Total	25, 060, 786	43	4, 616	905	2, 553

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[1] Roads and trails.

TABLE 5.—*Areas and total cost of forest fires on Indian Reservations*

Year	Area	Suppression cost	Damage	Year	Area	Suppression cost	Damage
	Acres	*Dollars*	*Dollars*		*Acres*	*Dollars*	*Dollars*
1910	634, 101	31, 249	897, 587	1922	42, 043	47, 289	27, 937
1911	20, 841	3, 060	16, 989	1923	47, 394	60, 539	25, 307
1912	12, 504	4, 319	11, 581	1924	31, 101	22, 489	69, 388
1913	144, 536	11, 171	36, 634	1925	53, 946	50, 910	67, 337
1914	117, 173	14, 543	76, 983	1926	64, 553	51, 749	34, 521
1915	40, 354	5, 803	62, 637	1927	133, 287	92, 328	126, 532
1916	54, 492	10, 175	55, 448	1928	23, 333	32, 208	28, 739
1917	121, 791	30, 036	62, 887	1929	46, 249	47, 336	78, 602
1918	71. 968	11, 871	37, 139	1930	57, 160	61, 683	126, 398
1919	87, 201	32, 649	292, 135	1931	124, 324	136, 393	227, 564
1920	227, 869	27, 468	384, 739				
1921	140, 231	38, 808	205, 878	Total	2, 296, 451	824, 076	2, 952, 962

It is impossible to furnish at this time, detailed estimates as to the probable cost of adequately protecting Indian forest lands from fire. The average area burned over annually during the fiscal years 1927 to 1931, inclusive, has been about 75,000 acres. In the judgment of Indian Service foresters this average acreage could be reduced at least to 40,000 acres, and to accomplish this objective an annual appropriation of about $450,000 is needed for the next 10 years. A large amount of this annual appropriation would be expended for permanent improvements such as roads, trails, and lookout towers, and in addition reasonable protection would be given to valuable timber resources which are producing many millions of dollars in revenue to the Indian owners as well as affording thousands of workers an opportunity to earn a livelihood.

CONTROL OF INSECTS AND DISEASE

Infestations of insects and epidemics of disease which damage and kill standing timber are not peculiar to Indian reservations. In fact such plagues are usually, if not always, of such scope and magnitude that they occur simultaneously and in common on national forests, national parks, Indian reservations, private lands and the public domain.

The most serious outbreaks now being combated are probably the white pine blister rust, and the ponderosa pine bark beetle. There is very little western white pine on most Indian reservations, but the bark beetle has seriously threatened timber on the Klamath Reservation in Oregon since about 1920. In 1922 funds for suppression and control of this pest were requested jointly by the Departments of Agriculture and the Interior.

In this work the Government departments were joined by private operators, since timber on lands owned by all three was infected. There has been expended on the Klamath Reservation since 1922 about $118,000 on insect-control work, of which about $75,000 has been spent by the Indian Service, about $40,000 by the United States Forest Service, and $3,500 by the Bureau of Entomology of the Department of Agriculture. The control work has followed recommendations of experts of the Bureau of Entomology. Twenty thousand dollars for insect control work on the Klamath Reservation was appropriated for the fiscal year 1933.

In 1912 approximately $5,000 was spent on insect control work on the Tongue River Reservation in Montana, but funds were not available for this purpose in subsequent years until 1931 when about $1,300 was expended.

Plagues of insect infestations and disease epidemics affecting standing timber are usually wide-spread and constitute a national menace. Funds for control work should be obtained and expended in suppression activities in such a way as will insure a high degree of correlated action between Federal, State, and private interests whose timber holdings are threatened.

DEVELOPMENT OF PERSONNEL

When the forestry branch of the Indian Service was organized in 1910, a personnel program was contemplated (*6*, p. 475) providing for the employment of a forester, assistant forester, and superintendent of logging, whose duties were to be those of general inspection and supervision; 3 men to have similar duties within 3 assigned portions of the United States which were described as comprising the Southwestern, the Northwestern, and the Central States; about 12 or 15 forest assistants and lumbermen in charge of the forestry work on the more important timbered reservations under the jurisdiction of the superintendents of the reservations, and a force of about 112 forest guards and rangers under the jurisdiction of the superintendents on about 40 reservations having large forest interests.

In carrying out this program, which has been modified to some extent as circumstances demanded, considerable difficulty has been encountered in retaining the services of competent men because of inadequate salaries (minimized somewhat since the reclassification) and living conditions and the somewhat unusual working conditions. A forester in the Indian Bureau, to render efficient and satisfactory service must not only have technically trained and fully alert mental equipment, but must be able to recognize fully the peculiar problems confronting the Indian Service with respect to the Indian wards of the Government; must win the confidence and respect of these people; and be guided to a very large extent in his work by a consideration of the best interests of the Indians. Although the turnover in the total number of forestry employees has been relatively large, the generally satisfactory progress which has been made in forestry work on Indian reservations has been due in some measure at least to the fact that the turnover in employees in supervisory forestry work has not been as large as in the more subordinate positions. The Director of Forestry has been able to build up a force of technically trained men who have acquired an intimate knowledge of Indian affairs and who understand the importance of Indian forest property in a general program which has as its objectives the social, industrial, and economic improvement of the Indian race.

If forestry practice on Indian reservations is to be improved one of the outstanding needs for all forest activities is an increased personnel, particularly for forest-fire prevention and suppression, general timber sale administration, grazing administration, and forest improvement work.

COST OF FORESTRY WORK

Table 6 gives the best available data of expenditures for forestry work on Indian reservations by major funds and years since 1910. Forestry is but one phase of a complex Indian problem and, as has been stated above, is inextricably intertwined with other Indian Service activities. Because of these things, foresters in the Indian Service are called upon to perform many nonforest duties which, in some instances, require an appreciably large amount of their time. While some funds from tribal moneys (mainly the appropriation "Indian Moneys, Proceeds of Labor") have been used for forestry work and are not included in table 6, this amount is equalled if not exceeded by the moneys spent (in wages and other items) on nonforest activities from the forestry funds given in the table.

TABLE 6.—*Expenditures for all forestry purposes under annual appropriation*

Year	Industrial work and care of timber, forestry	Expense account, timber [1]	Total	Regularly employed foresters [2]
	Dollars	*Dollars*	*Dollars*	*Number*
1910	77, 741. 16	7, 080. 82	84, 821. 98	
1911	90, 000. 00	11, 572. 90	101, 572. 90	
1912	99, 132. 15	10, 150. 24	109, 282. 39	
1913	104, 675. 76	15, 297. 91	119, 973. 67	
1914	91, 966. 47	16, 252. 17	108, 218. 64	
1915	112, 819. 26	13, 236. 68	126, 055. 94	
1916	105, 221. 95	21, 967. 10	127, 189. 05	
1917	104, 834. 74	32, 746. 79	137, 581. 53	
1918	98, 824. 82	37, 472. 84	136, 297. 66	
1919	106, 625. 85	46, 109. 42	152, 735. 27	
1920	102, 800. 43	88, 478. 59	191, 279. 02	
1921	109, 077. 94	60, 623. 09	169, 701. 03	180
1922	89, 889. 59	50, 873. 02	140, 762. 61	175
1923	99, 455. 42	100, 190. 99	199, 646. 41	192
1924	95, 212. 25	153, 568. 33	248, 780. 58	190
1925	115, 625. 60	122, 442. 15	238, 067. 75	178
1926	106, 577. 23	167, 840. 15	274, 417. 38	176
1927	139, 939. 66	162, 407. 26	302, 346. 92	167
1928	97, 295. 39	196, 818. 55	294, 113. 94	125
1929	129, 353. 69	217, 701. 90	347, 055. 59	126
1930 [3]	166, 197. 26	240, 707. 43	406, 904. 69	135
1931 [4]	324, 427. 00	247, 769. 87	572, 196. 87	116
Total	2, 567, 693. 62	2, 021, 308. 20	4, 589, 001. 82	

[1] Authorized deductions from timber-sale receipts.

[2] In addition to which there are or have been approximately 10 "at large" employees and 3 or 4 in the Washington Office.

[3] All grazing activities taken over by forestry employees.

[4] Includes $50,000 for emergency employment on construction work (relief legislation) and an additional amount of about $50,000 of deficiency appropriation for forest-fire suppression.

CONCLUSION

The approximately 71 million acres of land (being very nearly equal to the combined area of all the New England States and the State of New York), which are the property of the American Indian and held in trust for him by the United States Government, are of very great importance in the Western States and regions in the timber and livestock industries. In formulating a national program of wise use of forest and range resources, this large area of Indian land, under the administration of one branch of the Government, is entitled to careful consideration.

Viewed not only from the standpoint of the Indians themselves but in terms of a national-forest and range-land policy, the crux of the present unsatisfactory situation on Indian lands in the face of which sound management plans can hardly be evolved and carried out is the instability of land ownership.

The discontinuance of the practice of allotting forest and range land should immediately be accomplished by means of legislation prohibiting further allotments of land of this character.

Repeated efforts have been made since 1910 to obtain legislation necessary to insure the stability of ownership of large areas of Indian forest land of such character that it should unquestionably be permanently maintained in consolidated ownership for forest production and water-conservation purposes. The act of May 18, 1916 (39 Stat. 137), creating the Red Lake Indian Forest of approximately 110,000 acres has been the only legislation so far obtained, although similar bills pertaining to the Colville, Klamath, Warm Springs, and Yakima Reservations were introduced in the second session of the Seventy-first Congress. Legislation of like character is needed for the Flathead, Fort Belknap, and Tongue River Reservations in Montana; the Neah Bay and Spokane in Washington; the Fort Hall in Idaho; the Hoopa Valley in California; the Shoshone in Wyoming; the Mescalero in New Mexico; the Navajo, Fort Apache, San Carlos, and Truxton Canyon in Arizona; and possibly for several smaller areas.

Bills covering these reservations should be introduced in the next session of the Congress. With the realization that the establishment of a permanent status for Indian forest lands is essential to their highest economic use for the Indians themselves, and is also the most desirable policy for the Nation at large, these bills should be actively supported by all who believe that the present forest situation in the United States calls for the adoption and carrying out of a conservative national policy.

The United States Government should restore, insofar as is practicable, the former unified tribal status of Indian forest and range lands, and should maintain in a tribal status these restored lands as well as the present area of tribal forest and range lands, should adequately protect them from fire, and fully preserve their protective character and improve their productive value.

Just as the act of February 26, 1927, authorizing the cancelation of fee patents on Indian allotments, was intended to correct insofar as possible a mistaken land policy, legislation to restore to Indian tribal ownership those parts of possible working units of forest land which have been alienated and are now in varied ownership which precludes their proper protection and economic use should be enacted.

This act should provide for the establishment of tribal forests in units of sufficient size to be managed economically and for the buying back and inclusion in such tribal forest land that was originally Indian tribal land but which is now owned by individual Indians or by whites. The price per acre should not be in excess of the going price of nonagricultural cut-over timberland in the immediate neighborhood and should be limited in the enabling act. Where possible tribal funds derived from the sale of timber should be used for this purpose, and where these funds are not sufficient gratuity appropriations should be made available.

That the regulations and policies of the forestry branch of the Indian Service, originally approved in 1911, were basically sound and conservative is generally recognized. These policies which have been modified and improved by subsequent regulations, should be extended and intensively carried out. To this end larger appropriations are needed for additional improvements and equipment and an increased personnel, the details of which would require a larger amount of investigation and analysis than has been possible in preparing this report.

The efficient functioning of the forestry branch will be materially aided when funds and personnel are available for the collection and compilation of reliable and complete statistical data on all forest resources and all details of costs and administration. In fact, administrative officers cannot exercise proper control without such data. The lack of sufficient funds and personnel for this purpose has constantly handicapped the forestry branch of the Indian Service and this situation should be immediately remedied.

The public has, through the Congress, given its approval to the acquisition of large areas of mismanaged private forest production and protection lands by the Government; for the incorporation of these lands into new national forests; and for the extension of existing national forests. The public good clearly justifies this program of enlargement of the national forests. The general public is clearly interested in and must be responsible for the maintenance of an adequate supply of timber in the United States; for the protection of watersheds (the source of its water for domestic use and the protection of millions of dollars of invested capital in irrigation and power projects) and for the regulation of streamflow; for the prevention of destructive erosion of range and agricultural land; and for the maintenance of forested areas of inestimable recreational and inspirational value to the entire body politic.

Into this national picture the 71 million acres of Indian land fit with such perfect clearness that the public responsibility is inescapable. Many Indian tribes are possessed of great natural resources which are not susceptible of individual allotment and which from the standpoint of sound national economy should be preserved in large working units so that they may be conserved and used effectively (*9*).

It is self-evident that the National Government should properly conserve and use those areas of forest and range land now under its jurisdiction. The welfare of the Indians and the public good demand the prompt correction of easily discernible errors of legislation and administration of Indian lands which have resulted in the breaking up of the unified ownership of large areas of forest and range lands; which have made impossible the proper protection and economic use of these lands; and which have forced or will force many thousands of acres of forest and range land through the gamut of Indian ownership to private ownership and finally to swell the total of nonproductive, unprotected, tax delinquent, and tax foreclosed land. Unless remedial action is promptly taken, these conditions, which are deplorable from the national standpoint of conservation and wise use, will constantly become aggravated and more extensive. Not only will damage measured in dollars by millions have been done, but the proper management of these lands will be postponed for several decades at least, if it is ever possible.

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THE NATIONAL PARKS AND NATIONAL MONUMENTS

By Robert Marshall, Collaborator

SIGNIFICANCE OF PARK FORESTS

The national parks of the United States proper contain more than 4 million acres of forest, which is less than 1 percent of the forested acreage of the country. A goodly share of these stands are slow growing and on inaccessible sites. From a commodity standpoint, therefore, they are of little significance. Because so many of them are located near the headwaters of important rivers or in very mountainous country, they have a great significance in the regulation of stream flow and the prevention of erosion. All animal life is protected and consequently national parks are among the most important game refuges in the country. Their primary value is recreational and educational. Many of the finest scenic features in all America are included in the national park system.

Consequently, the national parks, although they only embrace about one third of the forest area so far set aside for recreational use, are usually distinguished in the American mind as the acme of forest beauty. This reputation has been earned by the high standards which have generally been maintained in the establishment of national parks. With few exceptions the national parks are confined to areas sufficiently magnificent to attract to them people from all over the country. With few exceptions each exhibits the finest example of some particular type of outdoor beauty. In most cases they contain primitive growth conditions and are over the larger part of their areas accessible only to those who travel by primitive transportation methods.

These unusually high standards make the national parks peculiarly important for those whose objectives are to derive inspiration, to commune with nature, or to study nature in its unaltered state. The visitors to national parks tend to remain longer than those to any other type of recreational forest land. Transient holiday outings, which furnish the principal use of municipal, county, and often State parks, are of secondary importance in most national parks. Exceptions are Yosemite National Park, which receives great patronage from nearby centers of population, and Mount Rainier National Park where the bulk of the visitors come from the neighboring cities of Seattle and Tacoma. Generally, however, national-park recreationalists seek something more than just having a good time in the outdoors. They are in search of the highest aesthetic values which nature has to offer.

The total area of the national parks is 8,433,422 acres, of which 4,353,298 acres is forested. Deducting the timbered acres in the Hawaii and Mount McKinley National Parks, there remains

4,155,218 acres of forested land in the national parks of the United States proper. This area is small in comparison with the 495 million acres of commercial forest land in the United States. From a recreational standpoint, however, this modest area of forest has unassessable value.

The Great Smoky Mountains National Park is largely forested; the area of its timberlands is at present estimated at 285,720 acres. Of the remaining parks, Yellowstone, Glacier, Yosemite, and Sequoia are the most important from the forest standpoint. Together they contain more than three fourths of the forested land in the entire national-park system.

Table 1 shows the names, locations, dates of establishment, areas, and special superlative characteristics of the 22 national parks at present in existence.

TABLE 1.—*National parks as of January 1933*

Name	Location	Date established	Area	Area forested [1]	Superlative characteristics
			Acres	*Acres*	
Acadia	Maine	1919	11,994	9,368	Granite mountains rising almost straight out of ocean.
Bryce Canyon	Utah	1928	35,240	12,500	Canyon exhibiting fantastic erosion and superlative coloration.
Carlsbad Caverns	New Mexico	1930	719	----------	Largest and most magnificently decorated caverns in United States.
Crater Lake	Oregon	1902	160,333	116,000	Lake in extinct volcano with remarkable coloration and almost sheer lava walls.
General Grant	California	1890	2,536	2,500	Fine grove of big trees including second largest tree in world.
Glacier	Montana	1910	981,681	785,280	Rugged mountain region of unsurpassed Alpine character, with precipices thousands of feet high.
Grand Canyon	Colorado	1919	645,809	110,000	The greatest example of erosion, and most sensational canyon yet discovered.
Grand Teton	Wyoming	1929	96,000	24,000	Superlatively rugged granitic exhibit, rising almost sheerly for thousands of feet.
Great Smoky Mountains.	North Carolina, Tennessee.	1930	297,720	285,720	Most rugged eastern mountain range; largest virgin timber tract in East.
Hawaii	Hawaii	1916	156,800	28,800	Active volcanoes, one of which is considered by many as outstanding volcanic exhibit of world.
Hot Springs	Arkansas	1921	945	800	None.
Lassen Volcanic	California	1916	104,527	60,000	Only active volcano in United States proper.
Mesa Verde	Colorado	1906	51,333	33,600	Most notable and best-preserved prehistoric cliff dwellings in United States.
Mount McKinley	Alaska	1917	1,939,493	169,280	Highest mountain in North America.
Mount Rainier	Washington	1899	241,782	101,000	Most famous volcanic peak and largest accessible single-mountain glacier system in the United States.
Platt	Oklahoma	1902	848	----------	None.
Rocky Mountain	Colorado	1915	259,411	123,000	Example of central Rocky Mountains at their best.
Sequoia	California	1890	386,560	226,000	Greatest collection of big trees, largest individual tree in world; highest mountain in the United States; remarkable mountains and canyons.
Wind Cave	South Dakota	1903	11,819	2,500	None.

[1] There is a distinction between land forested and that classified as forest land. The total of those areas of national parks classified as forest land is 4,420,000 acres.

TABLE 1.—*National parks as of January 1933*—Continued

Name	Location	Date established	Area	Area forested	Superlative characteristics
			Acres	*Acres*	
Yellowstone	Wyoming	1872	2, 200, 240	1, 658, 850	More geysers than in remainder of world; remarkable waterfalls; deep and gorgeously colored canyons.
Yosemite	California	1890	752, 744	562, 500	Valley of world-famed beauty; highest waterfall in America; remarkable cliffs and mountains; 3 groves of big trees.
Zion	Utah	1919	94, 888	41, 600	Magnificent gorge.
Total			8, 433, 422	[1] 4, 353, 298	

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[1] There is a distinction between land forested and that classified as forest land. The total of those areas of national parks classified as forest land is 4,420,000 acres.

FIRE PROTECTION

The average national-park area burned over annually during the past 5 years has been 19,072 acres. This represents 0.23 of 1 percent of the present total area of 8,433,423 acres. Practically all of the area burned was forested land.

The average annual expenditure on fire suppression for the 6 fiscal years 1927–32 has been $95,324. The National Park Service estimates the amount needed annually for the next 5 years at $175,180. This includes $63,214 for the current fire-prevention service and maintenance. The remaining $111,966 is required for permanent protection improvements, including trails, lanes, firebreaks, motorways, telephone lines, water developments, fire-equipment caches, storehouses, lookout towers and houses, cabins, and barns. These improvements, the National Park Service believes, would make it possible to reduce materially the acreage burned over annually.

INSECT CONTROL

National Park Service insect-control activities are discussed in the section of this report entitled "Protection Against Forest Insects." In general the insect-control policy provides for very intensive protection from insect epidemics on areas of high scenic value, heavy use, and unusual fire hazard, and where research is being conducted. The policy appears to be adequate, but the funds now available are insufficient to carry it out.

NATIONAL MONUMENTS

The National Park Service, in addition to its management of the national parks, has 38 national monuments under its jurisdiction. These vary in size from less than 10 acres to 2,697,590 acres. Their total area is 4,408,931 acres, of which only a little over 1 million acres is timbered. Practically all of this acreage is contained in the two immense Alaskan monuments, the Katmai and the Glacier Bay. In addition, 18,500 acres is included in the United States proper.

National monuments may be divided into five classes: (1) Remains of prehistoric civilization, (2) historic relics, (3) geologic examples,

(4) botanic reservations, and (5) wild-animal reservations. At present the last category is not represented in the system. The act of June 8, 1906, which authorized the establishment of national monuments specifies that they "shall be confined to the smallest area compatible with the proper care and management of the objects to be protected."

The national monuments administered by the National Park Service are listed in table 2.

TABLE 2.—*National monuments as of January 1933*

Name	State	Date established	Area	Area forested
			Acres	*Acres*
Arches	Utah	1929	4,520.00	
Aztec Ruins	New Mexico	1923	25.88	0.25
Bandelier	do	1932	26,026.20	10,000.00
Canyon de Chelly	Arizona	1931	83,840.00	
Capulin Mountain	New Mexico	1916	680.37	200.00
Casa Grande	Arizona	1918	472.50	75.00
Chace Canyon	New Mexico	1907	21,512.37	
Colonial	Virginia	1930	2,707.30	1,035.00
Colorado	Colorado	1911	13,749.47	
Craters of the Moon	Idaho	1924	49,601.90	700.00
Devils Tower	Wyoming	1906	1,152.91	1,000.00
Dinosaur	Utah	1915	80.00	
El Morro	New Mexico	1906	240.00	100.00
Fossil Cycad	South Dakota	1922	320.00	
George Washington's birthplace	Virginia	1930	394.47	73.58
Glacier Bay	Alaska	1925	1,164,800.00	500,000.00
Gran Quivra	New Mexico	1909	610.94	423.77
Grand Canyon	Arizona	1932	46,034.00	
Great Sand Dunes	Colorado	1932	46,034.00	
Hovenweep	Utah-Colorado	1923	285.80	
Katmai	Alaska	1918	2,697,590.00	500,000.00
Lewis and Clark Cavern	Montana	1908	160.00	
Montezuma Castle	Arizona	1906	160.00	40.00
Muir Woods	California	1908	426.43	426.43
Natural Bridges	Utah	1908	2,740.00	2,700.00
Navajo	Arizona	1909	360.00	15.00
Petrified Forest	do	1906	90,302.37	
Pinnacles	California	1908	4,906.61	1,500.00
Pipe Spring	Arizona	1923	40.00	1.00
Rainbow Bridge	Utah	1910	160.00	
Scotts Bluff	Nebraska	1919	3,240.09	200.00
Shoshone Cavern	Wyoming	1909	210.00	
Sitka	Alaska	1910	57.00	
Tumacacori	Arizona	1908	10.00	.25
Verendrye	North Dakota	1917	250.04	2.00
White Sands	New Mexico	1933	142,987.00	
Wupatki	Arizona	1924	2,234.10	
Yucca House	Colorado	1919	9.60	
Total			4,408,931.35	1,018,492.28

PUBLIC DOMAIN AND OTHER FEDERAL FOREST LAND

By Lyle F. Watts, Director Northern Rocky Mountain Forest and Range Experiment Station

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HISTORY

THE PERIOD OF LAND DISPOSAL

The first attempt by the United States to give legal status to a comprehensive system of land disposal was predicated on a belief that the public lands should all pass to private ownership and that the sale of these lands would furnish a gigantic source of revenue, adequate to finance the major part of the cost of government. The public-revenue feature did not long survive as a major purpose, but the policy of universal private ownership persisted until late in the nineteenth century.

Universal private ownership of land, with the widest possible distribution, was the aim of most of the land laws enacted prior to 1891. The following laws, among many, were passed in furtherance of this policy: The ordinance of 1784, the military bounty (script) laws, the homestead law of 1862, the timber culture law of 1873, the timber and stone law of 1878, and the desert land law of 1890.

Not only was every encouragement given to the passage of land title from the Federal Government direct to the private individual but provisions were made for the passage of title through a third party. The land grants so lavishly made for the purpose of encouraging colonization and development of the West were directed to ultimate private ownership. Practically all grants included stipulations so designed as to encourage sales to individuals in tracts of the small size then thought to be suitable for separate home units. The various public-land States in their statehood charters and in subsequent legislation were given an immense area for public education and for various State institutions. Very large grants were made to individuals, corporations, and local governments as subsidies for the construction of wagon roads, waterways, and railroads. Swamp lands to the extent of 64 million acres were granted to States in the expectation that they would be reclaimed through drainage.

THE PERIOD OF RESERVATIONS

Late in the nineteenth century a few far-sighted men began to realize that the natural resources of the Nation were being rapidly dissipated and that immediate and decisive action was needed to stop the processes of destructive exploitation. It became apparent that private ownership could not be expected properly to protect those national values which do not return to the individual a direct, tangible, and relatively early profit. Under the policy in force, the future timber supply was being jeopardized by wasteful and needless exploitation, both on private land and by trespass cutting on the public domain. Large and destructive forest fires were permitted to destroy great quantities of timber each year, with no concerted effort at prevention or control. No action was being directed toward retaining the forest cover on watershed lands in the interest of regulating the flow of navigable rivers or of streams intensively used for irrigation. Clearly, private owners recognized no responsibility for proper management of timberlands with a view to future national welfare. Public ownership without adequate provision for the protection of the resource from misuse, theft, and destruction by fire, insects, or disease was no better.

Appreciation of the need for conserving forest resources made rapid headway under exceptionally strong leadership and found concrete expression in a drive for the withdrawal from entry of lands having high natural-resource value. An act of March 3, 1891, authorized the President to set aside public timberlands as forest reserves. By the end of Roosevelt's administration in 1909, national-forest status had been given to a total gross area of 167,677,749 acres of land in the continental United States. Some area has since been added, but the elimination of tracts found by careful land classification to be unsuited or unnecessary to the purpose contemplated had by June 30, 1932, reduced the gross area in the national forests to 164,752,300 acres. The net area as of that date was 140,003,966 acres.

The desirability of reserving public-domain areas of peculiar scenic interest was recognized as early as 1872, when the Yellowstone National Park was created. It may properly be said, however, that the establishment of reservations on a large scale was inaugurated as a means of conserving the forest resource. The reservation principle was rapidly broadened to include other resources as well. The act of 1897, which provided for practical administration of the national forests, stated that the forests were maintained "for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of lumber for the use and necessities of the citizens of the United States." Reservations on a large scale have since been made for other than national-forest purposes.

In all, approximately one fifth of the original public domain has been reserved for the Nation's welfare. Some idea of the extent and character of the reservations may be afforded by the following list, although the list is incomplete and involves material overlapping:

	Acres
National forests	140, 003, 966
National parks	6, 329, 753
National monuments	303, 880
Indian lands under Federal jurisdiction	71, 144, 214
Coal-land withdrawals	29, 825, 444
Potash-land withdrawals	9, 411, 939
Reclamation withdrawals	19, 034, 330

The various acts sanctioning public-land disposal encouraged progressive removal of the best of the timberland from the public domain. The selection of land for private ownership naturally took the cream of the timber, both as to accessibility and as to stand per acre. The withdrawal of the national forests, likewise, was specifically directed toward the selection of the best timberland then remaining in public ownership. The working out of the various land grants with their lieu selection privileges further tended to eliminate from public ownership desirable forest land. Thus the timberlands now remaining in the public domain are the residue from a century and a half of culling for private ownership and the withdrawal of slightly more than 140 million acres as national forests. The extent to which this culling has gone will be appreciated from the fact that of the 1,441,436,160 acres originally in the public domain only 173,318,246 acres still remain, and of this remnant only a little more than 2½ percent is classified as commercial timberland.

THE PRESENT PUBLIC DOMAIN

Slightly more than 23 million acres of the public domain, the unreserved and unappropriated Federal land, are classified as forest land; only 4,629,000 acres of it, however, supports a stand of commercial timber. The remainder of this forested acreage is occupied by timber too poor in quality or quantity or too inaccessible to justify exploitation. Large areas below the altitudinal range of commercial timber support only a scattered scrubby tree growth; included among these are large areas of piñon or juniper in the Southwest. Other areas once were covered with commercial timber but as a result of fire and excessive cutting are now incapable of restocking naturally within a reasonable period. A small part is alpine in character. Substantially all the timberlands, both commercial and noncommercial, have a high value for watershed protection.

Perhaps 50 million acres of land in addition to the 23 million acres classified as forest land is of great importance, because of the character of its cover, in controlling erosion and stream flow. This includes such areas as the brush fields of California and the aspen-brush areas in Utah and south Idaho.

The public domain is very largely confined to the 11 far-western States. Table 1 shows that of the 173,318,246 acres remaining only 1,059,867 are located east of the one hundred and fourth meridian. The fact that only 22,000 acres of the public-domain lands in the East are classified as commercial timberlands, and that no comprehensive examination of the remainder has been made to determine their true influence on stream flow and erosion, precludes the possibility of specific recommendations for their disposal.

TABLE 1.—*Timbered areas of the public domain*

State	Commercial timber areas	Noncommercial timber areas	Total public domain [1]
	Acres	*Acres*	*Acres*
Arizona	None	1,820,000	13,581,760
Arkansas [2]	None	None	175,924
California	None	745,000	15,712,567
Colorado	1,937,000	2,321,000	7,467,597
Florida [2]	None	None	32,303
Idaho	537,000	421,000	10,865,472
Minnesota [2]	None	190,000	269,451
Montana	319,000	272,000	6,238,429
Nebraska [2]	None	None	20,225
Nevada	54,000	8,000,000	51,221,934
New Mexico	None	3,410,000	13,615,150
North Dakota [2]	15,000	25,000	142,694
Oregon [3]	1,001,000	200,000	12,920,334
South Dakota [2]	7,000	5,000	419,270
Utah	308,000	1,116,000	25,197,820
Washington	112,000	326,000	708,363
Wyoming	339,000	17,000	14,728,953
Total	[3] 4,629,000	18,863,000	173,318,246

[1] Acreages as of June 30, 1932; report of U.S. Land Office.

[2] States east of 104th meridian. Total area, 1,059,867 acres.

[3] Exclusive of O. & C. R.R. and Coos Bay Wagon Road grant lands.

The volume of commercial timber on the public domain is small in comparison with the Nation's total timber supply. Estimates recently made by the Forest Service on the basis of the best available data place the total stand at slightly more than 20 billion board feet. As will be shown later, the primary value of the greater part of the forested portion of the public domain is in its relation to erosion and stream flow and its use as range for livestock.

"Prompt and effective action must be taken if the value of very much of the remaining public domain is not totally to be lost." This statement is quoted from the report of the Public Land Commission appointed by and reporting to President Roosevelt. In the more than 20 years since this report was made, and in spite of continued pressure, no constructive policy for the proper management of public-domain lands has yet been adopted. Until suitable legislation is passed, the lands will remain without any measure of effective administration. Thus one tenth of the land area of the Nation remains a "no-man's land" to be used or abused by anyone.

TIMBERLAND MANAGEMENT

The legal possibilities for the practice of effective silviculture on the public domain are indeed limited. Acts of June 3, 1878, and March 3, 1891, authorized the removal, under permit, of limited quantities of timber without charge if they were removed strictly for personal use. An act of March 4, 1913, provided for the sale of dead and down timber without restriction as to intended use. No provision has yet been made for the orderly cutting of the mature timber crop, and almost no provision is made for the administration of such cutting as results from the acts referred to above. The nearest approach to a provision for forestry practice is the interpretation of the above laws which permits of pooling community needs. This enables a mill owner to contract to cut in one operation the supply of timber needed by several families. Reimbursement must be limited to payment for services and proof must be submitted that no charge is made for the timber as such. While this method of handling cutting is of some community benefit it cannot be applied except on a very small scale.

As might be expected, the volume of timber disposed of under these various acts is too small to play any definite part in the timber situation of the Nation or to make any worth-while contribution to community business. During the fiscal year ending June 30, 1931, there was a total of 11 sales of timber the total value of which was $2,582.52. During the same period 112 permits were issued for the free use of timber.

Widespread trespass cutting has occurred on the public domain, particularly during the period of colonization and initial development of the West. Railroad construction, home building, mining development, and other new business enterprises required a large quantity of timber. There being no legal means of obtaining green timber from the public domain and no sentiment adverse to the theft of public timber, trespass cutting resulted. Unfortunately this cutting was usually of the type most destructive to forest values and the devastation often was made complete by broadcast slash fires of either intentional or accidental origin. No value was then attached locally to the possibility of future crops of timber and therefore no effort was made to insure regeneration of the stand. Large areas were so thoroughly denuded that they have since reverted to grass or brush cover and are not now considered forest land. This reversion is well illustrated by conditions in the California foothills, where over large areas the lower timber line has been pushed back more than 10 miles.

The volume of timber cut in trespass has generally exceeded that cut legally; however, it has long since dropped to the point where it is of little consequence. During the fiscal year ending June 30, 1931, action was taken for the removal in trespass of timber, coal, gravel, and turpentine in 1,664 cases for a total value of $23,164.32. The portion of this amount chargeable to timber trespass is not known, but the total from all sources is extremely small considering the number of actions involved. (It is safe to assume that only a small percentage of the cases of trespass on the public domain are discovered and prosecuted, as the areas making up the public domain are widely scattered and are not systematically supervised.)

Prior to 1919 the Federal Government recognized no obligation to control public-domain fires. The limited field force of the Land Office gave the question of fire control such attention as time would permit, but effective action was precluded by the fact that no funds were available for this purpose. In 1919 a series of large and disastrous fires originating on the public domain in central Idaho threatened or actually spread to near-by national-forest or private lands. The situation became so acute that the Government made funds available to meet the emergency, of which $160,000 was spent.

The 1919 situation established a precedent, and except in the fiscal year 1921 the Government has made some financial provision every year since then for fire control on the public domain. Beginning with the fiscal year 1927 a portion of the appropriation has been made available for fire prevention. The extent of Federal expenditures for forest-fire control on the public domain is shown in table 2. The funds, although they have increased more or less steadily, are entirely too small to give the areas proper protection from fire. Whereas $65,000 was appropriated for the purpose in 1932, adequate protection as represented by that given to comparable areas on the national forests would call for an annual expenditure of about $725,000. This figure covers the protection needs of brush and woodland watershed types as well as of the remaining timberlands.

TABLE 2.—*Expenditures by the General Land Office for fire control on the public domain*

Fiscal year	Prevention	Suppression	Total
	Dollars	*Dollars*	*Dollars*
1920		160,000.00	160,000.00
1921			
1922		3,781.92	3,781.92
1923		452.45	452.45
1924		1,664.35	1,664.35
1925		9,686.58	9,686.58
1926		2,683.73	2,683.73
1927	12,275.25	10,546.78	22,822.03
1928	19,071.86	63.10	19,134.96
1929	41,318.94	69.62	41,388.56
1930	36,271.34	11,027.51	47,298.85
1931	56,017.35	3,841.14	59,858.49
1932	56,962.30	8,370.79	65,333.09
Total	221,917.04	212,187.97	434,105.01

The Government maintains no organization for the control of fire on the public domain. The activities which it finances to protect public-domain lands from fire are restricted to areas intermingled with or adjacent to private lands the owners of which have organized fire-protective associations. Such associations have been formed in heavily timbered parts of California, Oregon, Washington, Idaho, and Montana. They are authorized by State laws and participate in Federal aid through provisions of the Clarke-McNary law. They employ fire-control forces and use them much as does the national-forest administrative organization, prorating the costs to the various timberland owners on an acreage basis. Where there is public domain timberland within the association districts the Federal Government cooperates on the same basis as any other owner, except that its appropriations are insufficient to meet its obligation in full and that it takes no active part in the affairs of the organization. Federal funds made available for this use are assigned at the discretion of Land Office officials. This arrangement is as logical and businesslike as need be so long as the appropriations are too small to provide the needed degree of protection to all public-domain lands or even to those for which payment for protection is made in part. The maximum returns in protection are thus being obtained from the money available. It is a regrettable fact that the Federal Government does not afford protection to the greater part of the public domain.

RANGE MANAGEMENT

In most of the public-land States livestock raising is one of the largest business enterprises. The extent to which the range resource contributes to local welfare and the degree to which the carrying capacity of the range is maintained are vital to the stock grower. In spite of pressure for regulation and control, the use of this immense range pasture resource remains unregulated. Public-domain range is a free grazing commons, subject to all the abuse that such a condition encourages. No attempt is made to restrict the number of stock grazed to that which the range can support without deterioration.

No control is exercised to prevent use of the range during the early period of forage growth when cropping by livestock is disastrous to the vitality of the plants and when maximum damage results from trampling. No distinction is made as to the kind of stock for which the forage produced on a given area is suitable. Finally, absolutely no consideration is given to the interdependence of range land and valley ranches, a factor vitally influencing the stability of the livestock industry in the West. The relation of the public domain to watershed protection and its relation to crop agriculture in the irrigated valleys are ignored.

Under present conditions, portions of public-domain range the use of which is necessary for the maintenance of the financial security of established nearby ranches are often used by transient herdsmen at a time of year when maximum damage to the forage results and for grazing classes of stock not suited to the available forage. Improper use has depleted the cover to an alarming degree.

On many areas the more desirable forage species have been weakened or have been entirely killed out, often to be replaced by unpalatable weeds or even poisonous plants. Accelerated soil erosion, which inevitably follows such abuse, has reduced the productivity of the soil to such a degree that in many instances a long period of time will be required to rebuild it. On the area draining into the Rio Grande between the Elephant Butte Dam and the Texas State line, for example, according to recent estimates the vegetative cover has been depleted as much as 75 or 90 percent.

Practically the whole 23 million acres of forested land and also the 50 million acres of watershed brush lands in the public domain are used as range for livestock. Owing to the low timber values involved, in most instances greater returns can be expected from the use of the forage than from the use of the timber as a commodity. It must be kept in mind, however, that timber and range use can be practiced simultaneously on the same area. Such range use as is now being made of the public domain ignores the permanent value not only of the forage but of the timber and watershed resources as well. It is urgent that the proper steps be taken to correct this condition.

Two instances of range management on the public domain deserve comment. The Pumpkin-Mizpah area in eastern Montana and the Owen Valley area in California are being given a type of management very similar to that practiced on similar lands on the national forests. In these two instances owners of adjacent ranches have leased, under special legislation, not only the public domain but all the other lands within the boundaries of the topographical unit. An advisory board of the users involved determines the number of stock to be grazed, the season of use, and the method of livestock management. While it is too early to reach a final conclusion, the system seems to offer some promise where it can logically be applied.

WATERSHED MANAGEMENT

Although range forage is of the greatest immediate concern to the local communities, conservation of the water resource is of greater long-time importance. The area suitable for cultivation in the far-western States is greatly disproportionate to the available supply of water for irrigation, without which successful agriculture is generally impossible. In most parts of the far West the degree to which a permanent crop agriculture can be developed is immutably dependent on complete conservation and utilization of the water resource. Conservation and utilization of the water resource is limited by the degree to which watershed conditions that will insure the greatest flow of usable water are maintained and the extent to which engineering works to impound and hold unseasonable water flows are financed. Proper management of the public-domain watershed lands is part of this problem.

Maintenance of the vegetative cover is of prime importance in stream-flow regulation. Not only does the forest or other vegetative cover exert a very direct influence on the timeliness and quantity of the annual flow from the watershed, but it is the only practical means of controlling at the source the silting of reservoirs and irrigation works in general through the processes of erosion. On comparatively level agricultural lands erosion can, of course, be held in check by terracing, check dams, and proper crop rotations. Such measures are, however, of limited application on the immense area of watershed lands in the West. On these lands the stability of the soil depends almost entirely on the effectiveness of the forest or other vegetative cover.

The preceding discussion has pointed out that the forested public-domain lands have not been placed under management. Obviously the present condition of the lands is ill suited to the protection of watershed values. Unregulated cutting of timber, lack of control of forest fires, and excessive and untimely use of the forage resource together contribute to the destruction of the vegetative cover and correspondingly affect adversely its natural function of controlling stream flow and erosion. Past use of these lands has been entirely without regard for the watershed problem and has so impaired watershed values that only through years of wise, careful management can this resource be rebuilt to something approaching its original usefulness.

DISPOSAL PLAN

President Hoover, recognizing the urgent need for a final solution of the public-land problem, in 1929 appointed the Commission on the Conservation and Administration of the Public Domain. At the request of this Commission the Forest Service prepared and on November 8, 1930, submitted detailed recommendations covering (1) portions of the area that should be added to existing national forests or included in new national-forest units, hereafter called class 1; (2) portions that should be given national-forest status without intent of immediate administration but for eventual use as nuclei around which to build up logical administrative units, or be available for exchange for private lands needed to consolidate permanent public properties, hereafter called class 2; and (3) portions that should, in public interest, be placed under some form of public control in units designated otherwise than as national forests, hereafter called class 3. (Class 3 is included in the present report only because of the watershed-protective function of the 10,065,506 acres of timberland and the large area of nonforested watershed lands which it includes.) The recommendations of the Forest Service regarding disposal of the public domain were stated in that report as follows:

There are certain very definite advantages to continued public control of the open grazing [and public domain timber] lands of the Western States under systematic management and in conformity with the best determination of research and experimentation. First, it will guarantee adequate conservation of the natural resources, the best practicable protection of watersheds and irrigation projects, the most effective utilization of the forage resources, the best protection of such timber resources as may be involved, the application of the principles of range [and timberland] use and management through which the greatest permanency and productivity may be derived, the equitable distribution of the resources * * * to promote maximum community development and growth.

In general, the lands under discussion have inherent limitations of productivity. Aside from their mineral values, they contain no great stored-up treasures of natural wealth awaiting release through the agency of private initiative, which, as a matter of fact, has pretty well exhausted the possibilities of exploitation. The capacity of these lands to contribute to the support of county and State governments also is limited. No change in ownership will in the immediate future markedly increase the contributions now made by these lands to local costs of government. To a vast extent the lands present a problem of recreation of actual or potential wealth creating power which will require long, patient, and expensive regeneration, which only after many years and large outlays will lead to a restoration of their capacity for broad social service. They are an economic problem and responsibility rather than an economic opportunity.

* * * In its major aspect, that of water-resource conservation, the problem in large part is essentially an interstate problem.

Administration by whatever agency undertaken should be a constructive and creative process employing and applying all of the facilities that science, research, experimentation, executive action and direct supervision have to offer. It should be instructive and educational rather than coercive, accomplishing its objectives through direct field contacts and examples. It should be systematically organized with clearly defined objectives and definite programs for their attainment. It should not be passive and indifferent, or be based upon legalistic and contractual control from central offices with only remote contact with problems and persons, or conducted along traditional lines without full realization of the possibilities for progress.

Proper solution of the stupendous problems inherent in the public-domain States requires a technical organization within which permanent membership may be maintained only by the possession and development of the technical abilities required in the solution of technical problems. It should be a widely decentralized organization with its personnel so distributed as to bring them into direct personal contact with the problems demanding solution. Authority should be so delegated as to permit of immediate local action and decision upon local problems without reference to remote headquarters. The conduct of financial and contractual activities should be arranged so that delay is reduced to the absolute minimum. Through the development of many cooperative associations of users and the establishment of advisory boards representative thereof, the principle of local regulation should be definitely and widely established * * *.

The question of the proper type of administration reduces itself to one of collective and cooperative action. The lands under consideration are a part of the national estate and their preservation from destructive forms of use is therefore a general public responsibility. They constitute the watersheds of many important reclamation projects, the maintenance of which under optimum conditions is of vital community interest and of large concern to State and Nation. Steps, therefore, are proposed to set up a machinery of public control whereby the proper balance can be maintained.

The report from which the above was quoted designated by specific areas those parts of the public domain which should be included in each of the three classes described in the foregoing. Table 3 summarizes by States the area included in each classification.

TABLE 3.—*Disposal plan for remaining public domain*

State	Total	Commercial-timber areas	Noncommercial-timber areas	Nonforested water shed [2]
TO BE ADDED TO NATIONAL FORESTS (CLASS 1) [1]				
	Acres	*Acres*	*Acres*	*Acres*
Arizona	2, 756, 321	None	1, 820, 000	936, 321
California	2, 438, 964	None	423, 135	2, 015, 829
Colorado	3, 205, 443	1, 800, 000	1, 400, 000	5, 443
Idaho	2, 150, 447	186, 107	390, 725	1, 573, 615
Montana	905, 100	231, 900	102, 800	570, 400
Nevada	1, 684, 410	54, 000	1, 419, 000	211, 410
New Mexico	1, 826, 623	None	1, 626, 000	200, 623
Oregon [3]	584, 297	110, 394	110, 394	363, 509
Utah	2, 248, 960	278, 040	1, 046, 464	924, 456
Washington	89, 403	21, 194	45, 424	22, 785
Wyoming	1, 127, 242	320, 000	17, 000	790, 242
Total	19, 017, 210	3, 001, 635	8, 400, 942	7, 614, 633
TO BE RESERVED IN NATIONAL-FOREST STATUS (CLASS 2)				
Arizona	None	None	None	None
California	516, 646	None	52, 465	464, 181
Colorado	194, 257	75, 000	110, 000	9, 257
Idaho	295, 380	14, 500	30, 000	250, 880
Montana	112, 300	83, 900	21, 300	7, 100
Nevada	15, 695	None	None	15, 695
New Mexico	56, 717	None	23, 000	33, 717
Oregon [3]	1, 412, 332	684, 495	93, 553	634, 284
Utah	41, 880	5, 500	7, 660	28, 720
Washington	485, 756	87, 193	280, 281	118, 282
Wyoming	30, 584	10, 000	None	20, 584
Total	3, 161, 547	960, 588	618, 259	1, 582, 700
TO BE PLACED IN OTHER CONTROL AREAS (CLASS 3)				
Arizona	10, 825, 439	None	None	----------
California	12, 756, 957	None	269, 400	----------
Colorado	3, 548, 817	62, 000	800, 000	----------
Idaho	8, 419, 645	336, 393	275	----------
Montana	3, 956, 700	3, 200	146, 900	----------
Nevada	49, 521, 829	None	6, 581, 000	----------
New Mexico	11, 731, 810	None	1, 761, 000	----------
Oregon	10, 923, 705	None	None	----------
Utah	22, 906, 980	24, 460	61, 878	----------
Washington	None	None	None	----------
Wyoming	13, 571, 127	9, 000	None	----------
Total	148, 163, 009	435, 053	9, 620, 453	----------

[1] The location of class 1 land is shown graphically on a map included in the section of this report "The National Forests."

[2] The area of brush-watershed land included in class 3 is large but undetermined.

[3] Exclusive of O. & C. R.R. and Coos Bay Wagon Road Grant Lands.

This plan would place all except 2,976,480 acres of the remaining public domain under some form of satisfactory public management. Of the area not included within the three classes only an insignificant portion is timbered. Much of it is in small tracts intermingled with private holdings and under proper legislation might pass to private ownership. In any event the acreage unaccounted for is not of sufficient importance to justify great concern over its ultimate disposal.

COST OF ADMINISTRATION

The following estimate of the cost of administering, protecting, and improving the public-domain lands in a manner that will satisfy the true requirements of each of the three classes is based on experience in managing similar lands in the national forests. The cost of administration for each disposal class will vary considerably as between States, depending on such factors as topography, fire hazard, probability of erosion, and present range condition.

National forest additions (class I), 4.75 cents per acre; total cost, approximately $900,000.

National-forest additions (class II), 4.24 cents per acre; total cost, approximately $138,000.

Public control areas (class III), 1.21 cents per acre; total cost, approximately $1,812,000.

PROBABLE RECEIPTS

The immediate receipts which may reasonably be expected from these lands are small. The present depleted condition of most of the lands, resulting from abuses previously discussed, makes the present problem one of rehabilitation. Efforts to obtain immediate receipts should be subordinate to the task of rebuilding the property to its original usefulness and productivity.

On the basis of charges now being made for timber, forage, and special uses on the national forests and in view of the depleted condition of the property, it is believed that the revenue immediately obtainable is substantially as follows:

Resource	Proposed national-forest additions	Proposed national-forest reservations	Other proposed public-control areas
Timber	$68, 540	$14, 255	$2, 325
Grazing	331, 646	185, 875	481, 315
Special use	10, 515	4, 285	2, 300
Total	410, 701	204, 415	485, 940

OREGON & CALIFORNIA RAILROAD AND COOS BAY WAGON ROAD LAND GRANTS

Two properties in western Oregon, aggregating nearly 2½ million acres, are in somewhat unusual legal and financial status.

The Oregon & California Railroad land grant, known briefly as "O. & C. lands", included the odd-numbered sections within a strip extending 20 miles on each side of the right of way, and an indemnity strip extending an additional 10 miles on each side. The Oregon & California Railroad line, running from Portland, Oreg., to San Francisco, Calif., is now a part of the Southern Pacific Railway system. The terms of the grant provided, among other things, that the lands should be sold to any applicant for not more than $2.50 per acre and in units not exceeding 160 acres. The grant to the Coos Bay Wagon Road Co. was made on approximately the same terms, but involved a much smaller area. Compliance with the terms of the grants was poor. Applications for the purchase of small blocks were refused, blocks above the stipulated size were sold, and prices were raised above that stipulated. This defeated the intent of the act. For these and other reasons, the Government brought suit against the railroad and wagon road companies in Oregon, and the grants were forfeited. An act of June 9, 1916 (39 Stat. 218), revested in the

United States the title to approximately 2,354,000 acres of land previously constituting parts of the O. & C. grant. An act of February 26, 1919 (49 Stat. 1179), authorized acceptance from the Southern Oregon Co. of a reconveyance to the United States of approximately 92,000 acres of land previously constituting parts of the Coos Bay grant.

The acts of Congress under which these lands are administered provide that they be classified as follows:

Class I.—Lands chiefly valuable for water-power development, the timber upon which may be sold.

Class II.—Lands containing not less than 300,000 board feet of timber on each 40-acre subdivision, upon which the timber may be cut and the land subsequently opened to homestead entry.

Class III.—All land not falling within the other two classes, which is open to homestead entry on payment of $2.50 per acre.

According to the report of the General Land Office for the fiscal year 1931, the status of the O. & C. lands is as follows:

1. Power-site lands: 57,143.23 acres, containing 825,754 M board feet of timber, are embraced in power projects or withdrawals for power-site purposes. The Federal Power Commission has jurisdiction over these projects and withdrawals under the Federal Water power act of June 10, 1920.

2. Timberlands: 2,886,327 M board feet of timber on 95,963.29 acres has been sold to private individuals and corporations in the manner provided by the revestment act and by acts amendatory or supplemental thereto; 30,585,257 M board feet of timber on 1,132,062.61 acres remains unsold.

3. Agricultural lands: 1,069,279.72 acres of land has been classified as agricultural in character. This total includes 13,343.60 acres of lands which were originally in class 2 but which automatically reverted to class 3 when the timber was removed.

The status of the agricultural lands is as follows:

	Acres
Patented	206, 829. 45
Embraced in pending entries	81, 946. 07
Vacant, but subject to entry	780, 504. 20
	1, 069, 279. 72

An additional 2,758 acres has been withdrawn for recreational purposes at the instance of counties and the State of Oregon.

It appears from this report that the United States still retains title to 2,065,673.33 acres of land on which remains unsold 31,411,011 M board feet of timber.

According to the same report, the status of the Coos Bay Wagon Road Co. lands at the end of the fiscal year 1931 was as follows:

1. Power-site lands: 5,110.87 acres, containing 181,460 M board feet of timber. The timber, however, is subject to sale under an act of June 4, 1920 (41 Stat. 758).

2. Timberlands: 55,803.77 acres, containing 2,177,302 M board feet of timber. Of this, 14,908.83 acres, containing 608,749 M board feet of timber, have been sold to private individuals and corporations under acts of February 26, 1919 (40 Stat. 1179), June 4, 1920 (41 Stat. 758), and May 17, 1928 (45 Stat. 597), leaving 40,894.94 acres with a stand of 1,568,553 M board feet of timber unsold.

3. Agricultural lands: 31,378.15 acres. Of this area 8,841.15 acres have been patented, 5,927.48 acres are embraced in pending entries, and 16,609.52 acres are vacant.

Of the revested Coos Bay Wagon Road grant land the United States still retains title to 62,615.33 acres supporting a stand of 1,750,013 M board feet of timber.

MANAGEMENT

The classification of the land reacquired from both grants, except for water-power sites, takes no cognizance of the physical suitability of the land for agricultural purposes or for permanent forest use. Nor is there provision for holding any class II and III land in permanent public ownership. Sale of the timber is directed, but no provision for the permanent forest productivity of the land is required. Over 33 billion feet of commercial timber remains unsold on the class II lands; most of this land is primarily suited only for timber production.

Of the million and more acres in class III (agricultural), about three quarters has not been taken up by homesteaders, being unsuitable for agricultural development on account of soil, topography, or climate; this is however "ultimate forest land", for the most part of high productivity. Much of the class III land which has been covered by homestead entry has been promptly abandoned once the timber was removed.

The checkerboard distribution of these lands does not lend itself to proper management. For the most part they are the odd-numbered sections, alternating with private lands or with lands in national forests or some other form of Federal ownership. A few townships have been consolidated by exchange with private owners.

The United States Forest Service is authorized to provide fire protection for these lands. Units protected directly by the Forest Service receive the same treatment as national-forest lands; units outside the national forests are protected through contractual agreements with States or with the private association in whose areas they fall, and receive the same treatment as the commingled State and private lands.

No appropriations have been made to protect the timber on these lands from insects or disease. In southern Oregon this situation has been troublesome. A heavy infestation of bark beetles has killed immense quantities of ponderosa pine. The loss from this cause is estimated to be about 10 times the loss from fire in the same region. Oregon & California Railroad lands in the infested area cannot be neglected without nullifying control work on the surrounding lands; control measures which have been carried on for a number of years by private landowners and by the Forest Service, the Indian Service, and the National Park Service have of necessity been extended to cover Oregon & California Railroad lands. The total expenditures by all agencies since 1924 on the unit within which the Oregon & California Railroad lands lie have been approximately $100,000.

Logging practice on these lands invites strong criticism. Only the timber is sold; the land remains in Federal ownership. The operator has no incentive for conservative logging or continued protection.

RECOMMENDATIONS

National public interest requires that this great and valuable domain now in temporary Federal control be classified according to highest permanent use, and that portions chiefly valuable for forest purposes be placed in stable public ownership for technical administration on a sustained-yield basis. The problem is complicated by the scattered distribution of the property and by the financial equities of the States, counties, and Federal Government prescribed by existing legislation.

RESEARCH IN THE UNITED STATES FOREST SERVICE, A STUDY IN OBJECTIVES

By Earle H. Clapp, In Charge, Branch of Research

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CONSOLIDATION AND SEGREGATION

The Branch of Research was established in the Federal Forest Service on June 1, 1915, by Henry S. Graves, who was then Chief Forester. This action was a part of a more or less sweeping reorganization of the work of the Department of Agriculture which began a few months earlier. The general purpose of the departmental reorganization was in the words of the order putting it into effect to obtain "greater efficiency by definitely outlining or segregating within each bureau" the three main departmental activities, regulatory, research, and extension. While the Forest Service has little or no regulatory work in the commonly accepted sense of the term, it has instead a large administrative responsibility for the handling of the national forests.

The establishment of the branch of research involved the recognition by the Forest Service, among other things, of the following:

1. The need for forest research, if the main responsibility and objective of the Forest Service to bring about the full use of all forest lands of the United States and of its products and services is to be met.

It was a recognition of the fact that only by means of research would it be possible to obtain in the shortest possible time and at the lowest possible cost the basic knowledge necessary: To bring about the productive use of forest land for timber growing; to place and keep forest products in a position to compete with other materials in present-day industry—which is relying more and more upon research—and thus to insure a demand for the products grown; to insure the full recognition and use of forests and other vegetative cover in the regulation of stream flow, the prevention of erosion, and the production of water crops or the combination of water, timber, and forage crops; to bring about the productive use of forest ranges for the grazing of domestic livestock where consistent with timber growing and watershed requirements; to put the forest in a position to meet the growing needs for recreation; to obtain full recognition of its function as a home for wild life; and in general to make forest lands and forests render the largest possible economic and social service.

2. The Federal obligation and hence that of the Forest Service for the part of this research consisting primarily of national, interstate, and regional problems regardless of land ownership, and also of more local problems of the federally owned national forests.

The Federal obligation is based upon the need for making the national forests, which constitute more than one sixth of our total area of forest lands, of maximum public service. It is based upon the possibility of insuring profitable use for the five sixths of the forest land now largely in private ownership. It is based upon the need for finding more profitable use in forests for an area of submarginal agricultural land which may aggregate as much as 80,000,000 acres. It is based upon the fact that many forest problems have important national, interstate, and regional aspects. It is based upon a growing appreciation of the size and complexity of the entire forestry enterprise, upon a critical time element, and upon the need for national leadership which the Federal Government alone can furnish. In short, the Federal obligation has many things in common with that in agriculture proper which is the justification for a large amount of work in the Department of Agriculture. The concentration of much of the Federal forest research in the Forest Service is the direct result of the concentration in the Forest Service in large part of the responsibility for the forestry activities of the National Government.

3. That, most satisfactorily to meet the need for forest research and the Federal obligation for a part of it, as well as most satisfactorily to meet the needs of national-forest administration, research activities in the Forest Service must be consolidated and administrative and research activities must be segregated; that research work and personnel must be given a status equal to those of other Forest Service activities; that the activities concerned "should be so organized and related that each will reinforce and foster the other."

Research of a general or extensive character was one of the earliest if not the first activity of the organization which, in 1905 with the transfer of the national forests from the Department of the Interior to the Department of Agriculture, became the Forest Service. During the 10 years following the transfer, the great task of placing the national forests under administration so completely absorbed the thought and activities of the Forest Service personnel that research was very largely ignored. By 1915 it had become almost wholly submerged in the effort to administer the national forests. It was scattered in several branches, the primary responsibility of which was national-forest administration. Research in silvics, for example, was in the branch of forest management; range investigations were in the branch of grazing; field stations except the Forest Products Laboratory and the range stations reported to administrative officers in charge of national-forest districts; separate stations were maintained for each class of work even in the same region and consequently correlation was extremely difficult. For forest-products research alone there was a separate branch organization devoted exclusively to research, but even in this case final responsibility rested in an assistant forester in Washington whose main responsibility was national-forest administration.

Research was so submerged, in fact, and so out of the thought of the rank and file of Forest Service personnel that its development was practically at a standstill. In organization, administration, finances, the selection and recognition of personnel, and in practically every other particular it was subordinated to the development and administration of the national forests.

Progress made prior to 1915 in spite of the handicaps of organization, has been invaluable in the subsequent development of research. The Forest Products Laboratory, thanks mostly to much greater administrative freedom, had been developed to essentially its present form. Several small forest experiment stations had been established in the West, local in their conception and designed primarily to serve national forest needs, but still experiment stations. Most of them were essentially the same as our present experimental forests. A handful of men had been developed as a nucleus around which to build a larger staff. A good deal of exploratory work had been done and substantial progress had been made in working out specialized technique adapted to the requirements of forest research. In many respects seed had been germinated which needed only the right kind of opportunity for growth and fruition. The development of research prior to June 1, 1915, is, however, an interesting and important story in itself, the telling of which will not be attempted here.

The reorganization of June 1, 1915, met the situation by recognizing research as a major Forest Service activity on a par with other activities, and like them, one which must stand on its own feet. It met the situation by segregating both administrative and research activities. The basic purpose in the Forest Service, as in other bureaus of the Department, was the greatest possible efficiency and the largest possible public service in both activities in the broadest and most far-reaching sense.

Under the plan for consolidating research activities and segregating administration and research, the Forest Service organization, in briefest terms, took the following form: The forest experiment stations became responsible for the organized research in specified regions, the Forest Products Laboratory for the work within its particular field over the entire country, and all reported directly to the Branch of Research, which in turn reported to the Forester. All the national forests in each of the several large regions continued to report to a district or regional office, which in turn was responsible to the Forester. This means that there are two sets of field organizations which have been made responsible for research and administrative work respectively in the same territory and which report independently to Washington.

Experience has shown that the gains to research through consolidation and segregation have far more than offset possible losses. One of the greatest losses has been through the elimination of such advantages as might accrue through the administrative handling of the work by experienced executives, men of ability who have risen to responsible positions.

One of the most important gains has actually been in supervision, although in some cases temporary dependence has been necessary upon much younger men or men with less supervisory experience. Forest research even in a preliminary or extensive form is specialized, and as the work increases in intensity becomes more and more highly specialized and over a widely diversified field. Supervision to be effective must be equally specialized. It must be highly sympathetic in order to insure the right atmosphere and the best conditions for work, and to obtain the most and best results. To give supervision of this character calls for men with research training and experience and background. It must have the major call upon their time and interest. It must be the main job of men who are responsible for research alone. Such supervision cannot be obtained as a side issue or an incidental interest. In fact, thoroughly competent and fully sympathetic supervision is one of the main essentials for effective research. The Forest Service learned through experience that, regardless of their ability, it could not and should not be expected from men whose main job was the administration of the national forests and whose experience, interest, and outlook were primarily or exclusively that of national forest administration.

One of the incidental gains to research from segregation has been to relieve investigative personnel of a large volume, in the aggregate, of miscellaneous incidental jobs which formerly detracted materially from their main effort, or research. They have been relieved from the necessity of being "handy men."

The segregation of research has meant freedom from pressure to justify the administrative practice, technical or otherwise, in use on the national forests. In many instances it has already led to the recognition of the investigative staff by the general public, and by financially interested sections of the public, as a wholly impartial organization. The importance of freedom in research to reach conclusions based on facts cannot be overestimated.

Probably the most important gain has been in the freedom to formulate objectives and to develop the research organization and policies to meet the specialized requirements of investigative work. These necessarily differ from national forest administration in such important respects as recruiting, financing, and many phases of supervision. This may sometimes have led to the feeling in the larger administrative group that such changes in policy or procedure, which had been developed in the Forest Service purely and simply from the administrative standpoint and regardless of how poorly they applied in investigative work, were unjustified and wrong in theory and practice. It has been at bottom, however, a recognition of different fundamental requirements for the most efficient conduct of two distinct classes of work having a single and very broad ultimate objective.

Experience has also shown that the gains to administration from segration have far more than offset possible losses. The greatest of these gains has been from the far more rapid development of research and from a far greater volume of information as a basis for a sounder national forest administration. The existence of a strong research group, critical by the very nature of its work and free and independent of the administrative force, has been and cannot help but be a wholesome influence on national forest administration. It is one of the best long-time safeguards which could be devised for preventing national forest administration from getting into ruts. On the other hand, the presence of an administrative group having no direct responsibility for research but needing its results and certain to be critical if it does not get them, is likewise a wholesome influence on the investigative staff. It compels research men to keep in mind that their function is service and that research is not an end in itself.

DEVELOPMENT OF ORGANIZATION AND FACILITIES

One of the problems resulting from consolidation and segregation, and one which has required a large amount of attention, has been the development of a sound organization in the broad sense and of effective administration as a means for doing the work for which the Branch of Research was established. This has involved such objectives as the most effective relationships between research and the administrative organization of the Forest Service, the most effective field units, the most satisfactory working facilities, adequate financing, a competent research staff, and effective supervision.

Organization and supervision are only necessary means to an end in research, and all objectives formulated for them must have this in mind. In general the more that organization and supervision can be kept in the background the better, and early settlement and settlement along sound lines of the questions involved is the best way to accomplish this. Sound and clear-cut objectives in organization and supervision help to insure a minimum of lost motion and the maximum progress and accomplishment.

THE MOST EFFECTIVE RELATIONSHIPS BETWEEN RESEARCH AND ADMINISTRATION

So that under the segregation plan administration and research would foster and reinforce each other in fact as well as in theory, it has been necessary to develop ways and means for maintaining the most effective relationship between the organizations responsible for the two activities.

One necessary means to this objective is that administration have a voice in the determination of what research should be done. Administrative officers have, therefore, been given a substantial share in formulating the programs on which the research is concentrated and also an opportunity to read and criticize reports covering investigative results. In other words, the segregation of research has been complete for the determination of research technique and the current administration of the research itself, but the work is on programs jointly recommended by administrative officers and the investigative staff.

A second means to this objective is provision for cooperation in getting investigative results into practice on the national forests. The administrative staff is responsible for application but can and should be aided by the investigative staff. Among the many forms which such aid takes are representation on boards which decide upon the details of the silviculture to be used in the cutting of national forest timber, on boards which review the handling of serious forest fires, attendance at conferences called to work out policies and technical management, assistance in special training camps for the administrative staff, etc.

A third means to this objective is provision for cooperation in getting investigative results applied on privately owned lands, or still broader, of furthering the practice of forestry on privately owned lands. Both the regional administrative organizations and the regional forest experiment stations have a very definite responsibility in these fields, although that of the former units is mainly to administer national forests and that of the latter is for research. In short, there is an overlapping of responsibilities in the relationships to the private owner and to the public in general which requires correlation. It is difficult to draw any clear-cut line between these responsibilities, although it has been clearly recognized that the major responsibility rests on the administration organization. With segregation of administration and research, as worked out by the Forest Service, satisfactory public contacts, including extension, must depend for success upon the good sense of the local Forest Service representatives directly concerned and upon a reasonable amount of give and take. The competitive element in the situation rightly handled has been and should continue to be stimulating and wholesome rather than injurious.

Still another means toward this objective is that both the administrative and research organizations contribute to major Forest Service policies. To this end major policies, regional and national, whether they involve administration of the national forests, relationships with private owners, or the conduct of research, ordinarily receive joint consideration.

Endless circumstances throw the administrative and research groups together in Washington and the field. Joint committees select on the national forests the areas for experimental forests and ranges and natural areas. The handling of experimental forests and ranges after selection is in some respects a cooperative undertaking. The committees which recommend programs for future research review the results of past research even before they are put into report form. Both research and applied forestry go forward simultaneously on many national forests. Junior foresters and junior range examiners are sometimes loaned from the administrative organization to research units. There is some exchange of personnel between the two classes of work, with the present trend mainly from administration to research, and of younger men for whom some administrative experience is a splendid background for a subsequent investigative career.

A final means to the objective of having administration and research foster and reinforce each other is afforded by the opportunity for having the two groups join forces in the occasional large undertakings that affect the whole forestry movement and that require for their most effective handling the knowledge, background, and experience of both groups. Congressional requests such as the Capper Senate resolution of 1920 and the Copeland Senate resolution of 1932, which require the broadest kind of consideration of the entire forestry field and the formulation of programs to meet outstanding national problems, illustrate undertakings of this character.

MOST EFFECTIVE FIELD UNITS

With the obligation for work on national and regional problems requiring investigations in all or nearly all forest regions of a country of continental size, concentration of all research of all classes in Washington or any other one place is obviously out of the question. Some decentralization and the establishment of some field units is called for. One vital organization question involved in the formulation of objectives has therefore been the determination of what kind or kinds of field units and how many of each should be established, and what their general organizations should be. The establishment of such field units is so far-reaching in its commitments as to time, costs, and the character and volume of results that it has been absolutely necessary that it be based on sound fundamental principles.

One of the most important basic principles taken into account has been the interrelationship and essential unity of all phases of forestry and hence of the research upon which the forestry enterprise must depend. For example, natural reproduction in ponderosa pine stands on the Coconino Plateau in the Southwest depends partly upon precipitation and other climatic factors. Abundant reproduction can be obtained only through the rare combination of an abundant seed crop followed by a year favorable for survival of the seedlings. Soil is another important and very complex factor, as is also competition of larger trees both above and below ground. In this particular part of the range of ponderosa pine, damage to forest reproduction from livestock grazing may be very severe and the conditions under which it occurs and the grazing management necessary to prevent it must be taken into account. Range use obviously depends upon the character and amount of the forage or subordinate forest vegetation, and this in turn is frequently an important competitor of forest tree seedlings.

Campaigns for the destruction of predatory animals are carried out to reduce losses of livestock, and apparently result in increased numbers of rodents, some of which consume large quantities of forest tree seed, others destroy small seedlings, others, such as porcupines, destroy large seedlings, saplings, and even larger trees, and still others feed upon forage plants. Game animals are related to forest perpetuation on the one hand and to range use on the other. Both range use and forest reproduction are definitely tied in to the necessity and the ease or difficulty of fire protection. Both entomological and pathological problems are almost inevitably involved in very complex and far-reaching ways. The conditions, such as density of stand, etc., under which timber is grown, have a very direct influence on both the quantity and the character or quality of the forest products produced. Any form of forest or range or game management modifies natural conditions, and sets up a chain of biological sequences which is likely to carry through the entire forest complex. And all of these things are reflected in the requirements and nature of research. All phases of management have their economic aspects, which in themselves are interrelated and which must also be reflected in research.

Under the southern rim of the Coconino Plateau another group of relationships and hence another class of forest research comes into the picture—the influence of vegetative cover on erosion and streamflow. The vegetative cover may be virgin or cut-over forest, or it may be that which follows the timber on devastated forest land. It may consist of chaparral or brush, or of forage grasses and other plants in the subordinate vegetation, or of different combinations of these. The brush and forage cover may have been materially changed through grazing. The water crop on which the Salt River Valley now depends promises to become an important or even the sole purpose of forest and range management in some parts of this rim country. Where it is the main purpose, specialized silvicultural measures may become necessary. The same thing may be true of range management. Where either is true it will be reflected in the research required.

The same kind of interrelationships and hence essential unity holds true of practically every broad forest problem in every type or region in the United States. Any plan for research units which ignores this interrelationship and unity cannot be otherwise than unsound.

It is essential to recognize as a second principle that whereas for some research, such as most forest products investigations, the materials to be investigated can be easily and cheaply transported to a central laboratory from all parts of the United States and centralization may be a distinct advantage by aiding correlation, for other forms of research too great distances may result in lack of contact with and knowledge of field conditions which should govern the character of investigative programs. In silvical or forest range or erosion-streamflow investigations, much of the work can be conducted only in the woods. In such work, in a country like the United States, distance becomes a factor which cannot be ignored.

The responsibility of the Federal Government for national and regional problems requires the recognition of a third principle, the establishment of units which will facilitate work on these problems and tend to minimize or exclude work on local problems, for which, elsewhere than on the national forests, State and other agencies are responsible.

A fourth principle calls for units which will insure the most effective administration at the lowest feasible cost. This necessitates a happy medium between units so large as to be unwieldy and so small as to be ineffective. It requires workable units in reasonable numbers instead of too few large units or a multiplicity of small units. It means units which will hold costs for overhead equipment, etc., to a feasible minimum.

The application of these principles has resulted in two classes of field units, and the formerly rather numerous units which did not fit into either class have gradually been eliminated. One of these classes is necessarily regional and the other is national.

The first class includes the regional forest or forest and range experiment stations. The plan has been to locate one such station in each of the important forest regions of the United States. Since for much of the work the woods or the range must constitute the laboratory, distance is one controlling factor. Even under the regional plan it is often great. For example, the territory of the Southern Forest Experiment Station is 1,100 miles long by 400 to 700 broad, and by the best rail connections it is a 36 hours' journey from the New Orleans headquarters to the southern tip of Florida. The Central Station territory is 800 miles long by 750 broad, and it is 24 hours by train from the Columbus headquarters to the western boundary of the region. The California territory is 815 miles long. In general the regions adopted are not so large but that all parts can be reached in a reasonable time and cost.

The principle of unity of all phases of forestry and hence of forest research is being recognized in two ways in the regional forest experiment station plan. The first is, so far as a rather complicated forest distribution permits, to draw the boundaries of each territory to include similar forest conditions. The second is to concentrate all kinds of research in each region at one station. As a result of the latter the work of the stations includes silvicultural or forest-management investigations, range investigations, studies of erosion, streamflow problems of both forest and range lands, studies dealing with forest economics, and in a few instances investigations dealing with purely regional forest-products problems. Recognition of the principle of unity means the best opportunity for the coordination of interrelated classes of research and the prevention of duplication. It means many-sided, well-rounded-out group attacks.

For reasons which are so obvious as hardly to require explanation, the regional stations also constitute the most effective units for the recognition of the third principle of Federal responsibility for regional and national problems. For the classes of work handled by the stations they are finally the most logical units to insure effective administration at the lowest feasible cost by avoiding both excessive size and excessive numbers.

Since the creation of the Branch of Research in 1915, six such regional stations have been established in the East, and five local stations in the West have been reorganized on a regional basis. Plans call for one or two additional stations in the United States proper and one each in Alaska, Hawaii, and the West Indies.

The second class of field unit includes only one institution, the Forest Products Laboratory, at Madison, Wis. The principle of unity is recognized by the concentration at the laboratory of a very large percentage of the entire Forest Service effort in products research, thus insuring correlation and effective group attacks. It is recognized further by a gradually increasing amount of work on borderline problems between products and silvics. The future promises to bring also a growing number of purely silvicultural problems which can be handled most effectively at a central laboratory such as can easily be developed and has long been planned at Madison as a part of the Forest Products Laboratory. It is apparent also that the economic problems closely related to the forest products field can be handled most satisfactorily from the laboratory.

Distance in most forest products investigations is of far less importance than in silvicultural and range investigations, because most forest products problems, such as timber testing and pulp and paper investigations, are of a character in which the investigative material can be brought to a single central laboratory without disadvantage and with material gain in efficiency and correlation. Concentration of the work at a single national unit tends to emphasize the principle of Federal responsibility for national and regional problems and to prevent work on purely local problems. The principle of the most effective administration at the lowest possible cost is also met most fully in forest products investigations by a single national unit.

The establishment of a single National Forest Products Laboratory in 1910 followed the trial over a period of years of regional or local laboratories, of which there were about 12, the first dating from 1891. Although such local laboratories have obvious advantages, such as local interest and closer contact with local conditions, they were finally abandoned because of excessive costs in equipment and personnel, including overhead, difficulties in the correlation of research, etc.

Under the existing organization in the Department of Agriculture, some classes of forest research are assigned to other bureaus than the Forest Service, and the field units described have the further advantage of permitting cooperative effort and a unified, well-rounded-out or group attack on the entire forest problem. Under this plan forest pathologists from the Bureau of Plant Industry, have been assigned to the Forest Products Laboratory, and pathologists from Plant Industry, forest entomologists from the Bureau of Entomology, and biologists from the Biological Survey have been assigned to several of the regional stations. The number is being gradually increased. All work under the direction of their own bureaus.

Since the basic interrelationship and unity of all classes of forest research is becoming increasingly apparent, more detailed illustration of the manner in which it is being recognized is justified, although this will involve some repetition of what has already been said. It has been necessary to provide for forest products research at some of our forest experiment stations, primarily on problems which have important local silvicultural aspects, such as the utilization phase of selective logging or mill-scale studies. The work on silvicultural problems at the Forest Products Laboratory, already mentioned, has led to the establishment of a Section of Silvicultural Relations. One of the important problems on which this section is working is the biochemistry of naval stores, a borderline problem which might be assigned either to the Southern Forest Experiment Station or to the Forest Products Laboratory, depending upon exigencies of finances, personnel, etc. Both the regional stations and the Section of Silvicultural Relations are certain to work on physiological problems. The laboratory and the stations are already in numerous instances joining forces in working out the relationship between growing conditions and the properties and quality of the final product, and in time this will be true in practically every forest region. Research in forest economics must inevitably be conducted at both the regional forest experiment stations and the Forest Products Laboratory. The Forest Survey is a large and important economic investigation which illustrates the interrelationship between silvicultural and products investigations and bridges in still another way any apparent gap between the forest experiment stations and the Forest Products Laboratory. In some of its aspects, such as the determination of actual and potential growth, it is closely related to and in fact merges into, the silvical research of the experiment stations, and in other of its aspects, such as present and probable future requirements for timber, is closely related to and merges into the work of the Forest Products Laboratory.

The range and silvicultural investigations at the regional experiment stations run together in such projects as the adaptations of range management necessary to insure reproduction of species like ponderosa pine, and as the influence of the vegetative cover where forest and forage plants occur in combination.

The growing realization of this unity and of the necessity of providing for it in investigative programs, in the administration of research, and in the organization of field units is one of the most striking lessons which has come out of the development in forest research in the Forest Service during the last 15 years.

The question is sometimes raised whether the regional forest experiment stations do not constitute a new national system of experiment stations with a different basic principle from that of the State agricultural experiment stations. Federal contributions to both agricultural and forest research take two forms—one of financial grants to the States, and the other, of direct Federal effort. In the latter the Department has over a long period of years been building up a strong, Federally supported and controlled research organization of which the regional forest experiment stations constitute a part. These stations are designed to meet the Federal responsibility for work on national and regional and national forest problems. If they give any appearance of a new and different principle it is only because the entire country has been covered in a plan-wise organization. The steadily growing volume of cooperation between the Federal and State stations is evidence of the fact that the two sets of stations constitute complementary rather than rival systems.

MOST SATISFACTORY WORKING FACILITIES

An essential requirement for good research is satisfactory laboratory and other working facilities, including headquarters. The determination of what facilities will best meet requirements constituted, therefore, another important question which had to be answered in the development of forest research. The answer constitutes another set of objectives.

The Forest Products Laboratory is maintained at Madison, Wis., in cooperation with the State university. It has, therefore, all the advantages from the standpoint of research of affiliation with a strong educational institution with a well-developed graduate school and an agricultural experiment station in both of which there is a large amount of research. The advantages, in brief, grow out of the stimulus which comes from the opportunity for formal consultation and informal contact with a large group of specialists in widely diversified fields and from the scholarly and research atmosphere of educational institutions. They grow also out of the opportunities for formal cooperation.

The university provided laboratory facilities for the Forest Products Laboratory for many years, until the organization completely outgrew the available space. Present needs have now been met and future needs anticipated by a recently completed Federal laboratory in the maintenance of which the university will cooperate. This, with periodic enlargements, should meet the needs for years to come.

The headquarters for the forest experiment stations have constituted another problem. Isolated headquarters were the rule in the early stages of our forest and range experiment station development, so that the men might live with their jobs in the woods or on the range—an unquestionable advantage. It was found, however, that small groups of men stagnated scientifically under such an environment, and the experience of other organizations has shown that even relatively large groups have the same tendency. The plan of isolated headquarters has therefore been abandoned, and headquarters have been placed in cities and wherever possible in direct cooperation with universities.

The headquarters of 6 of the 11 regional stations so far established are maintained in cooperation with universities, namely, the Allegheny Station in cooperation with the University of Pennsylvania, at Philadelphia; the California, with the University of California, at Berkeley; the Central States, with Ohio State University, at Columbus; the Lake States, with the University of Minnesota, at St. Paul; the Northeastern, with Yale University, at New Haven; and the Southwestern, with the University of Arizona, at Tucson.

For forest and range experiment stations maintained at universities, headquarters laboratory needs are being met in varying degree by the cooperating institution. The situation at stations without university affiliation is as yet far less satisfactory.

The major part of the silvicultural and range work must, however, be conducted in the woods and on the ranges. This requirement is now being met by a clear-cut departmental as well as Forest Service policy and instructions for setting aside from the existing national forests and dedicating to research both experimental forests and experimental ranges. Where there are no national forests, provision for acquisition or other arrangements are to be worked out.

Each experimental forest is to be as fully representative as possible of the conditions in an important subregion. So far as can now be foreseen, from 5 to 10 experimental forests will ultimately be required in each forest region in the continental United States and a smaller number in outlying regions. The McSweeney-McNary Forest Research Act specifies 13 such forest regions in the United States proper and 3 in outlying possessions. The area of each of the experimental forests will range from about 1,500 acres as a minimum to about 5,000 as a maximum, exclusive of natural areas. Housing and incidental laboratory facilities are needed and are gradually being provided at the experimental forests.

The same general policy is to be followed in the establishment of experimental ranges. Provision is also made for natural forest and range areas to form a part of experimental forests and ranges wherever possible, and for such other natural areas as may be necessary throughout the country for research purposes.

To date 15 experimental forests and 2 experimental ranges have been set aside by formal proclamation. Sixteen natural areas have been set aside and are available for investigative purposes. About an equal number of experimental forests and natural areas are in advanced stages of selection and formal establishment. Conditions in practically every forest region of the United States are represented.

The policy of formally setting experimental forests and ranges and natural areas aside in perpetuity grew from years of experience in which it was found that even on the national forests widely scattered sample plots could not be satisfactorily protected, resulted in excessive costs, did not in many instances lend themselves to the intensive research which frequently becomes necessary before problems can be satisfactorily answered, did not lead to satisfactory correlation of findings, were most unsatisfactory for demonstration purposes, and gave unsatisfactory results in many other respects. Experimental forests and ranges, with the bulk of the field research of the forest experiment stations concentrated on them, should within a relatively few years become invaluable for demonstration purposes as well as for the research for which they are primarily created.

From the somewhat scattered statements in the preceding pages regarding the component parts of a forest experiment station a more comprehensive picture may be drawn. A station consists for one thing of a headquarters in a town which serves for the permanent residence of the technical and clerical staff, which offers the opportunity for laboratory work, and which preferably permits affiliation with a high-grade educational institution with a strong graduate school. It consists also of a series of experimental forests each of which is as representative as possible of the conditions of an important subregion. Where range problems are involved, similar experimental ranges are utilized. These experimental forests and ranges are in fact branch stations at which the bulk of the field activities of the station are concentrated. Each station works on the problems of an entire region and covers silvicultural or forest management investigations, range investigations, those of forest and range influences, forest economics, and to a minor extent investigations of forest products, or all classes of forest research except those which can be handled best in a national unit.

To the stations also, wherever satisfactory arrangements can be worked out, representatives are detailed from the Bureau of Plant Industry for investigations of forest pathology, from the Bureau of Entomology for investigations of forest entomology, and from the Biological Survey for investigations of forest wild life.

ADEQUATE FINANCES

When the Branch of Research was established in 1915 only a relatively small amount of research was under way in the Forest Service. As the National Forest administration became more intensive and the forestry movement on lands in other ownerships gained headway, the size and complexity of the research job and the magnitude of the Federal obligation for even a part of it were gradually realized. With the rapid exhaustion of virgin timber supplies and relatively small effort toward their replacement, with the technique of timber growing largely unknown throughout the United States, with forest products at a decided disadvantage in competition with practically all other commodities because of lack of knowledge of their properties and how to use them effectively, and with enormous areas of land available for timber growing and apparently suitable for no other purpose, there seemed to be little question about the urgency of research. The conclusion was accordingly reached that the national interest required expansion of the work as rapidly as increased finances could be made available, provided, of course, that suitable personnel could be obtained and the organization developed to handle the work effectively. It had to be recognized that adequate finances constituted one of the main essentials or objectives for doing forest research. Before increased finances could be obtained, however, both the public and Congress had to be convinced that the work contemplated was actually necessary and in the public interest.

The effort to meet financial needs finally led, among other things, to the passage of the McSweeney-McNary Forest Research Act of May 22, 1928. In its broader aspects this legislation is the organic act for forest research in the Department of Agriculture, with all that this implies in recognition, standing, etc. A group of objectives, including the scope of the research, the field units at which it is to be done, and the 10-year financial program in accordance with which it is to be carried out, are given the full authority of congressional enactment. From the standpoint of the development of research in the Forest Service this legislation ranks in importance second only to the consolidation of the work in the Branch of Research and the segregation of administrative and research activities in the Forest Service.

The merit of the policy of adequate financing is not likely to be questioned except during a serious economic depression when Federal receipts are at a low level, the burden of taxation is severely felt, and public opinion is striking out at expenditures in general without very much consideration of their necessity or promise. The results of the policy must be judged on the basis of whether a scientific foundation for forest-land use or the lowest possible Federal appropriations are more in the public interest, and of whether the required effort could have been made by any other agencies. Finally, it should be borne in mind that the increases in appropriations indicated below were made during a period when adequate funds were available and that the amounts are insignificant in comparison with expenditures for other public purposes, or with the values at stake.

For the fiscal year 1915, $286,578 was available for all classes of research, and for 1932, $1,793,300, not counting cooperative contributions which would add about $100,000, nor $900,000 for a Forest Products Laboratory building, nor about $140,000 for emergency contruction purposes at the forest experiment stations. The average annual increase in appropriations for the 14 years preceding the passage of the McSweeney Act was about $55,000, while that for the 3 years, not including the depression year of 1933, following the passage of the act has been $250,000. The rate of expansion may be indicated still more specifically by classes of work.

The appropriation for forest management research in 1921 was $50,000; that for 1932 was $562,000, an increase of approximately 11 times in as many years. The appropriation for forest economics in 1925 was $25,800, while that for 1932 was $355,000, or an increase of nearly 14 times in 7 years. During the 15 years from 1917 to 1932 forest products appropriations increased approximately 5 times from $135,000 to $641,300. During the 5 years between 1927 and 1932 range research appropriations more than tripled, from $40,320 to $130,000. The first appropriation of $30,000 for erosion-streamflow research became available in 1930. That for 1932 was $100,000.

The expansion of the larger field units has been in proportion. Funds available for the Forest Products Laboratory between 1915 and 1932 increased from $130,744 to $534,430. The Southern Forest Experiment Station was established in 1922, with an initial allotment of $14,860 and the funds available in 1932 were $180,800. The Pacific Northwest station handled its work in 1922 with $7,040, and in 1932 was allotted $167,300. In 1926 the California station expended $7,085, and in 1932 was allotted $141,680. The Lake States station was established in 1924 with an appropriation of $23,555, and this had been increased to $103,390 in 1932. Field stations other than the Forest Products Laboratory received in 1921 a total allotment of less than $50,000, while in 1932 they received $1,048,580, a twentyfold increase.

The character of expansion is indicated also by the establishment of new units or the reorganization of small local units to a regional basis, and by the initiation of Nation-wide investigative enterprises. The Appalachian and Southern Forest Experiment Stations were established and the Northern Rocky Mountain Station was placed on a regional basis in the fiscal year 1922. The Lake States and Northeastern stations date from 1924. The Pacific Northwest station was reorganized on a regional basis in 1925. The forest taxation inquiry was organized in 1926. The California station was founded in 1927. The Central States and Allegheny stations were established in 1928. The forest survey was initiated in 1930 and the Intermountain and Southwestern stations were established on a regional basis in 1931.

The increase in finances has carried with it the initiation of lines of work some of which had been recommended regularly over long periods of years. The Forest Survey, for example, for which the initial appropriation was obtained in 1930 under the authorization of the McSweeney-McNary Act, was first recommended some 50 years ago. Provision for intensive studies of forest taxation and forest insurance, dates from 1926 and 1930, respectively, following the authority granted in the Clarke-McNary Act. For other classes of economic work repeated recommendations had been made over at least a 10-year period, but it needed the authorization of the McSweeney Act to make the first appropriations available in 1930.

With growth in appropriations there has been a corresponding expansion in the Branch staff. It now totals approximately 500 of whom 285 are technical. The increase is not in the same ratio as that of appropriations because of changes in salary level.

Probably few foresters in the United States realize how even under its present inadequate status the provision for forest research in the Federal Forest Service alone compares with that in other countries. Although full data from other countries is not available, a check of all the sources at hand in 1930 indicated current expenditures in all other countries of approximately $1,000,000. It is probable, therefore, that the 1932 appropriation of about $1,800,000 for the Forest Service equaled or exceeded expenditures in all other countries. This is a situation which has developed almost entirely within the last 10 years, and a substantial part of it since the passage of the McSweeney-McNary Act. It is not an indication that requirements are being met. As will be shown later in greater detail, in every region and in every field of research the projects on which nothing is being done or on which the attack is seriously inadequate far exceed those on which it is now possible to work or on which attack can now be made on an adequate scale.

As the result of the current economic depression, some of the financial ground gained has already been lost. The funds available for the fiscal year 1933 are about 10 percent less than those for 1932. A prolonged depression may seriously threaten much that has so far been gained.

COMPETENT MEN

Long years of experience have shown the hopelessness and the futility of attempting to do satisfactory research with mediocre or poor men, and hence one of the main essentials in building up a research organization is to have a thoroughly competent, adequately trained staff.

If the past few years prior to the depression can be taken as a criterion in Federal forest research, the possibility of obtaining qualified men, not the availability of money, has in fact been the controlling or limiting factor in the rate at which the work could be expanded. That the national requirements for forest research have not been met during the last decade is primarily because sufficient men with the necessary mental equipment and training have for one reason or another been nonavailable. The current economic depression raises a question as to whether this will continue to be true in the future—one which it is still too early to answer with assurance.

With men the limiting factor in the rate of expansion under normal economic conditions, either one of two decidedly different plans could be followed. Under one, appropriations could be sought and the work developed only as fast as well-trained and competent men became available in the natural course of events without special stimulus. This plan is commonly followed in developing research organizations. Most important among its adantages is probably the assurance of a better conduct of the research attempted. Among others, it is much less likely to lead to criticism, which is ordinarily of the way research is done rather than of the failure to do it on a scale commensurate with public needs.

The other plan was to make the requirements of the job, or in other words the public interest, the compelling consideration. The size, complexity, and urgency of the problem in the United States, or the public need, as indicated in the discussion of adequate finances, seemed to be sufficient justification under normal economic conditions for the expansion of the work as rapidly as possible.

But the adoption of the latter plan of making the public need the guiding principle in the development of research has created a difficult recruiting problem. In meeting this problem the requirements as to mentality for recruits to the investigative staff have been set very high. When sufficient men with adequate training could not be obtained, the balance of current needs have been met by the employment of men who have been only partially trained for investigative work. In short, the jobs have been created and made as attractive as the limitations of the Government service permitted in order to interest good men and to stimulate the training of such men for research.

The recruiting standards or objectives adopted call in every instance for obtaining the ablest man available in the forestry profession. Mentality, idealism, character, and all of the faculties and qualities which are necessary for the highest grade of research are taken into account. In training, the objective is a doctor's degree or an equivalent, but this is not as yet attainable in many cases. Efforts in the selection of every man even for the lowest junior positions go to great lengths. All the evidence which can be obtained from every possible source bearing upon qualifications is taken definitely into account. Such evidence is collected and contributed systematically to a central clearing house by every unit and every permanent employee in the organization. An effort is made to keep a running record of every young man in the profession whose work is outstanding. This goes as far back as the undergraduate record.

It has been found through systematic check that the civil-service record for junior positions is in the great majority of cases an excellent criterion of what may be expected in the subsequent career of individual men. Men who show up best in the junior examination almost invariably have a creditable subsequent career. Almost invariably the men who have failed to develop, who have become personnel problems, are those whose civil-service record is unsatisfactory.

Since it has been necessary, with inadequate numbers of fully trained men available, to employ substantial numbers of men before they are fully trained for research, training on the job has become an essential part of the effort to build up a research organization. That training on the job does not give some of the things that the schools do is fully realized, but if experience is any guide, its possibilities have been far too heavily discounted. Efforts for such training are made as systematic as possible, and include such things as care and diversity in research assignments, special supervision on them, details to other regions, special training for particular classes of work, etc.

Another move to stimulate the development of the investigative staff has been the discontinuance of year-long isolated headquarters, and location of the experiment station headquarters wherever the circumstances permitted, in direct cooperation with universities. Without doubt this has been a material factor in stimulating and broadening our personnel.

In recognition of the benefits of advanced college training for research, men who have not had such training have been encouraged at temporary sacrifices to the organization to go back for further training. Of the men in the research organization not yet fully trained a large percentage plan to take advantage of this opportunity at their earliest convenience.

Another phase of this effort is the temporary summer employment of forest school undergraduates. The number so employed annually already reaches from 75 to 100. The policy is to select only the best men, to develop in these men an interest in research as a carrer, to give them a background of research experience, and in general to make temporary employment one additional means of building up the ablest and best-trained staff available in the profession.

Practically no men were training for forest research in 1915 because there was little or no promise of a career if they did. The policy of placing public requirements ahead of other considerations in Forest Service research involved the deliberate creation of relatively large numbers of jobs. During each of the 3 years ending with 1932, men for 30 to 50 new positions were sought. The possibility of a career in research has been made as attractive as the limitations in the Government service will permit, as to salary, personal recognition for work done, desirable headquarters for permanent residence, etc.

As indicated above, the Forest Service demand for men has been one of the factors which within the last decade has revolutionized the situation in the forest schools of the United States equipped to give advanced training. The revolution has gone furthest in silvicultural work, but it has begun in forest economics, range, and other classes of research. Whereas 15 years ago, or even at the close of the war, there probably were not more than 2 or 3 men in the entire United

States who were studying for a doctor's degree in forestry, there were 32 men at 6 of our forest schools in 1929–30.

Five or six of these were in the field of wood chemistry and wood technology, several in the field of range ecology, and practically all of the others in silviculture and various aspects of forest ecology. Comparable data on the number of men working for master's degrees in preparation for research as contrasted with other phases of forestry are not available. Obviously the demand from other organizations than the Forest Service has accentuated the burden on the forest schools to supply in rapidly increasing numbers men thoroughly trained for the various kinds of forest research.

EFFECTIVE SUPERVISION

Another question involving the philosophy of organization and supervision which has had to be faced and settled, but which nevertheless keeps arising, is whether the work should be handled by individual or organized effort.

In many research organizations individual investigators under general or no supervision and with little or no coordination decide what they can and should do, follow out leads as they find them, and proceed without very much regard to what their associates are doing. Unquestionably this form of individual effort has many advantages, chief among which is the incentive arising from lack of restraint. It fails fully to take into account, however, such basic considerations as the need for group attacks because of the interrelationship of all phases of the forestry problem or its unity, and it fails to meet other requirements and responsibilities of a publicly supported research agency.

The plan of organized effort has accordingly been followed by the Forest Service. The determination of the programs on which work will be done is undertaken systematically once each year and programs so determined ordinarily remain in effect during the ensuing year. In reality the determination of such programs is an attempt to set up clear-cut objectives for a year's work. The members of investigative staffs are then assigned to the projects agreed upon in which it is believed, all things considered, they can render services of the greatest value. In short, wherever the nature of the work requires, the staff works as groups on those phases of the forest problem which, after careful consideration, are determined to be most in the public interest. This plan insures fully coordinated attacks on the most urgent problems, continuity of purpose and effort, and results of greatest value from the public standpoint, and, finally, makes it possible to render a satisfactory accounting to the public which finances the work.

Accomplishments to date under this plan unquestionably far exceed any conceivable progress under unrestricted individual effort. Furthermore, it has been found that sufficient leeway can be given for individual effort to satisfy nearly all investigators, individualistic though they may be.

The Forest Service handling of research differs in still another respect from that of many other research organizations in requiring that a carefully thought-out plan be put into writing for all the specific pieces of work or projects undertaken, at least after they have passed a preliminary exploratory stage. This for one thing makes it necessary to think out plans as fully as possible in advance of beginning work, with whatever advantage this may bring in avoiding mistakes. It permits criticism from other men. The scheme as followed is perfectly flexible in allowing or requiring the revision of plans whenever the development of the work calls for it. Without question this requirement also helps to insure the fullest possible correlation of the investigative work as a whole.

Dependence upon public funds has led among other things to the adoption of the principle of accountability, and there cannot be accountability without pressure on men who need it for the delivery of reasonable results. That this principle is regarded by many research organizations as inapplicable in investigative work or injurious to it is well known. Without any question accountability introduces difficult problems of supervision. Zeal and interest can in the great majority of cases be appealed to in men of the right sort when important questions of public interest are involved. Men who have the ability to render satisfactory services and who have the public interest at heart are not the ones who object. Rightly handled, periodic accounting need not interfere with individual initative and can be made as wholesome an incentive to good work in research as in any other human activity. In the last analysis the public that we serve has a right to ask that for every dollar expended at least an equivalent value in services be rendered and that appropriate means to insure this return be taken.

Finally, effective supervision requires conscious and continued effort to create and maintain the right atmosphere for research, the interest, the zeal, and in general the intangibles which are so large a factor in the character and quality as well as the quantity of work and which are perhaps more needed in research than in any other activity.

Organization, facilities for work, finances, men, and effective supervision are, however, merely a beginning. Taken alone they mean nothing. Singly and collectively they only pave the way for research. Research itself is only a means to an end. The end is human welfare.

PROGRESS IN RESEARCH AND THAT STILL REQUIRED

In the space available it is possible to discuss actual progress in research only in the most general terms. A compensating advantage should be a clearer picture of the broader aspects of the situation for the entire country. Because the major portion of Forest Service results have been obtained since the formation of the Branch of Research in 1915, the statement covers all results to date. The headings are by appropriation items and do not in all cases conform exactly to accepted professional terminology. The field which remains to be covered is discussed without reference to the obligation for it which rests on many agencies of which the Federal Government is only one.

FOREST MANAGEMENT

Forest management, one of the most important classes of forest research, determines how to establish, bring to maturity, measure, and protect forests or, in the broadest sense of the term, how to grow or manage forest properties. Research in forest entomology and forest pathology, although essential parts of this subject, are not discussed because they are administered in other bureaus of the Department of Agriculture.

NATURAL REFORESTATION

Although planting has the greatest popular appeal, it is on natural processes of regeneration that the forester must very largely depend for the perpetuation of the forest. Accordingly the latter has received by far the greater emphasis in research. For a rather large percentage of the most important forest types in the United States, research findings to date show in a fairly satisfactory way how natural reproduction can be obtained or how to reestablish the forest by controlling the method of cutting the mature forest. Or conversely, they show for most of our more important forest types how to prevent the forest devastation which has been such a widespread evil in the United States; and also how to prevent forest deterioration, which has been a less spectacular but probably an even greater evil. Some of these findings, as for example in the ponderosa pine, Douglas fir, and eastern spruce forests, involve significant adaptations of the standard European silvicultural methods to the requirements of American species and American conditions.

The work done in this and other connections has in the aggregate accumulated a rather impressive knowledge of the taxonomy and distribution of our forest trees, of the life histories and requirements of many of the most important species, and of the ecological relationships of many important single species and forest types. The ground to be covered is far greater than that which has been covered, but much of our silviculture of natural forest regeneration is no longer entirely blind and without fundamental foundation.

Looking at our needs in a broad national way, a very large field of work in the reestablishment of forests or in obtaining natural reproduction still remains. Much of the information so far obtained is empirical and too little progress has been made in breaking the problem down into its constituent factors, which is a necessary preliminary to an intensive attack. Far too little, to illustrate, has been accomplished in breaking down problems of light, soil, moisture, competition, physiological responses to environment, etc., as a basis for the evaluation of these factors through intensive research.

Much less progress can be shown on the problem of carrying established forest lands through to maturity, although a good beginning has been made. Large numbers of sample plots have been established, but nearly all are still too recent to render their fullest value. Thinning plots and those representing other cultural operations are fewer in number. In general, the work along this line is in a preliminary empirical stage.

As in the initial problem of establishing the young forest, practically everything is ahead in breaking down into its constituent factors the problem of carrying established stands to maturity, as a preliminary to intensive attack. Large additional quantities of both empirical and intensive work will be necessary before we shall be in a position to say with assurance what are the best species and mixtures for various conditions of soil, etc.; how we shall manage our stands to insure quantity or quality production or the right combination of both; the best relationship between silviculture and protection against fire, insects, and forest diseases; the relation of silviculture to erosion, stream flow, and other forest influences. In general, the larger and more important question of bringing forest stands to maturity has had much less attention than that of establishing young forests and preventing forest devastation or deterioration.

ARTIFICIAL REFORESTATION

Research in artificial reforestation has made substantial progress in laying the foundation for fairly satisfactory nursery- and field-planting technique for our most common and valuable conifers. For these species, in other words, we have made substantial progress in learning how to grow forest tree seedlings and establish forest plantations. The availability of this information means that planting with the species in question has far greater assurance of success than it would otherwise have.

On the other hand, the work has barely begun on what is perhaps the larger and much more far-reaching problem of carrying plantations to maturity, the ultimate measure of success. Still ahead is the research necessary for growing forest crops of the best species and mixtures that will give highest yields, or the best quality for particular purposes, or a desired combination of quantity and quality. An enormous volume of work is required for practically all species, types, and regions on such problems as the source of seed, planting sites, mixtures, density, etc. This is the information on which we shall in the last analysis have to depend to avoid failures and to insure ultimate success in growing timber.

The work thus far on artificial reforestation has been almost entirely on conifers. The development of a satisfactory technique for establishing hardwood plantations lies ahead, as does also the work on which we must rely to bring such plantations to maturity.

Time is a very important element in practically all aspects of silvicultural research on either natural or artificial regeneration, or on carrying established stands to maturity. The results cannot be hastened. The life span of trees is very long. Extreme climatic conditions which may occur only periodically often have a decisive influence on the forest. The oldest silvicultural plots have been in existence from 20 to 30 years, many more from 10 to 15 years, and the largest number from 5 to 10 years. Because of the relatively brief time since the establishment of sample plots, the potential promise of results probably outweighs the results already obtained; but in spite of this there has been a great although as yet intangible gain in the passage of time.

FOREST MENSURATION

The work in forest mensuration to date can claim the preparation of volume tables for approximately 50 species, and of yield tables for approximately 12 forest types which normally occur in even-aged stands. American foresters need not apologize for their contribution to a better technique in volume and yield table construction. Neither do they need to apologize for progress in the use of statistical methods as a tool in forest mensuration and other forest research. Practically all of the work, however, has been done in natural as contrasted with managed stands, although a small beginning has been made in the latter field through the establishment of permanent sample plots. Only a beginning has been made in the preparation of growth tables for uneven-aged stands.

Undoubtedly a good many years' work is ahead even within the fields touched upon in the preceding paragraph. The more intensive fundamental work on both volume and yields lies almost entirely ahead. Only a little has been done on the fundamental laws governing form or even on the first steps of breaking the problem down into its factors. Only preliminary information is available on the influence of such factors as wind, temperatures, soil mixtures, density of stands, cutting, etc., on form. The same general situation holds regarding the more complex yield problem. Even the conception of normal stands which has been the basis for much of our work to date on normal yield tables, is vague and poorly defined. Quality of the product, as contrasted with quantity, has as yet received practically no consideration in either volume or yield work.

FOREST-FIRE PROTECTION

Forest-fire research apparently originated in the United States, undoubtedly as the direct result of a forest-fire situation which is more serious than in almost any other country. Research of this character is gradually being taken up in other countries, and may now be under way in half a dozen. The problem is complex, and accordingly it is gratifying that progress has been made in breaking it down into parts that can be studied effectively.

Substantial progress has been made in the development of a technique for statistical studies of past fires and the efficiency of protective organizations. These and other studies are giving invaluable leads for improvement in fire control by pointing the way to better organization for the prevention of forest fires, for prompter detection, for extinguishing fires while small, and for the organization necessary to combat large fires. These studies are also paving the way to greatly improved hour-control or speed-of-attack standards, which is one of the essentials in the development of fire protection.

Studies of fire damage have proved invaluable as a means for combating the light-burning theory in several parts of the country where it has been a serious menace to forest management. Relatively little progress has been made, however, in an exact determination of what damage is caused by fire in all forest types and forest regions, which is one of the primary requisites for an intelligent distribution of protective funds and protective organizations.

With existing organizations many fires become large, and with the greatest possible gains in efficiency this may be expected to continue with a certain proportion of fires for years to come. Some effort has therefore been devoted to studies of the climatic and other conditions which influence fire behavior and of going fires, and corresponding progress has been made. A beginning has been made on forest fire meteorology with particular reference to electrical storms and to relative humidity. Progress has been made in a much more exact determination of the factors which may indicate bad or serious conditions. All of the work on fire behavior and on the factors affecting it looks forward as one important objective to the improvement of suppression tactics and technique. To the same end scattered effort has been devoted to the development of power equipment to speed up work and to reduce costs by replacing hand labor, which to date has been so largely used in fire suppression.

In a relatively few instances research has indicated the possibility that it may be advantageous or even necessary to use fire as a beneficial agent in silviculture. Research of this character, however, lies almost entirely ahead.

The possibility that the menace of forest fires may be reduced through silvicultural management, and that under some conditions the maintenance of the forest cover by the elimination of clear cutting may be the most effective means of fire prevention, has only been touched upon. The work done, however, suggests rather far-reaching modifications of silviculture, and in fact for some forest types the probability that future silviculture may be dominated by requirements for fire prevention.

Forest-fire research to date has, on the whole, been centered very largely on man power, finances, organization, etc., to prevent and minimize forest fires and to extinguish them. In general, forest-fire research is still in its infancy, and its achievements lie mostly in the future.

OTHER CLASSES OF MANAGEMENT RESEARCH

Other phases of forest management in which research can make important contributions but in which as yet far too little or practically nothing has been attempted include: Forest regulation, involving rotations, cutting cycles, and cutting budgets, which have both silvicultural and economic aspects; forest engineering, including such problems as permanent road or transportation systems for forest utilization but having important silvicultural aspects, and as road and trail systems for fire protection; and park forestry and city and town or shade tree forestry, both of which have important root, physiological, growth, and health problems in which there is a large amount of public interest. Before forestry in the United States can be on a wholly satisfactory scientific foundation much information must be available for many species on the relative merits of geographical strains. This, along with other information, is needed as a basis of seed selection for planting. There is a distinct possibility also of developing hybrids which will be superior to any existing species.

FOREST RANGE INVESTIGATIONS

If not the first, the United States was one of the first countries to undertake range research. This work of the Forest Service grew out of the widespread use of western national forest ranges by domestic livestock and has since been extended by departmental or legal dispensation to include other forest ranges as well as nontimbered western ranges. The justification for the work is the possibility of using the range as one of the important products of the forest.

The Forest Service has centered its work primarily on the range resource and the relation of range used to timber growing and watershed protection, and has taken up the problem of handling livestock on the range only incidentally. The use of native plants in most instances as a secondary crop which must be perpetuated and controlled by natural processes and skillful use and, in the West, at least, the necessity for handling livestock on open ranges of great extent in remote and rugged country, constitute markedly different problems from those of the ordinary cultivated pasture.

The work has resulted in the determination of the most important plants growing on the western mountain ranges as a whole, and has led to some general observational records of the forage value of different plants based upon the extent to which they are eaten by livestock. Aside from this it has so far been confined largely to the intermountain and the southwestern regions.

For a considerably smaller number of the more valuable plants in these two regions much more intensive information has been obtained on the growth habits, with particular reference to grazing use.

The work has developed some important general principles governing grazing use which apply with local adaptations to conditions throughout the entire West. Among these principles are the necessity for a very conservative stocking of the range on account of the striking decrease in growth of range plants during the periodical dry years or cycles; of allowing vegetation to make vigorous growth before being grazed; of giving bunch grasses periodic opportunities to reseed; of grazing sheep and goats openly and quietly and bedding them down in new places every night; and of obtaining better distribution of cattle on the range through well-placed watering places and better salting methods. A fair beginning has been made in a few localities on such fundamental questions as succession. Progress has also been made in determining the character and amount and also the cause of damage by livestock to forest reproduction and in working out forms of regulation to minimize or prevent damage.

The need for range research is by no means confined to the regions and types where it has so far been concentrated. Fortunately, increased appropriations made it possible to begin work in California and in the Northern Rocky Mountain regions during the fiscal year 1932. Investigations should at the earliest possible date be extended to other western types and regions and to eastern regions where, as in the South, range use now accompanies or can possibly accompany timber growing.

As contrasted with the long-time requirements of forest management for the growth of timber and cutting at intervals of several or many years, range management in the main involves the annual growth and use of annual or perennial plants. It requires knowledge which will permit the best species and mixtures of range plants to be maintained under use up to specified standards which must be determined. For depleted ranges it must also determine ways and means of restoration. Where timber production is the main objective, the possibility of range use depends upon whether timber can be grown successfully on the same area, and this must first be determined. The next step is the proper coordination of the two forms of use.

The more intensive research lies almost entirely ahead, and this among other things requires the breaking down of broader problems—plant succession, competitive relationships, soil productivity, physiological response to use, etc.—into factors which can be studied and evaluated in an exact way.

The large problem of range management will deal with native plants and natural revegetation. There is the opportunity, however, for artificial reseeding on which as yet only a few empirical tests have been made, and for the development of improved strains, and perhaps hybrids, etc., on which nothing has been done.

FOREST AND RANGE INFLUENCES

The limited number of attacks on the erosion-stream-flow problem on forest and range lands in the United States, initiated prior to the last decade, dealt with watersheds or duplicate watersheds as a whole, whether forested or range covered. Valuable information was obtained, but much that was necessary to a real understanding of the role of vegetative cover, forest and otherwise, in erosion control and stream-flow regulation remained very obscure because of offsetting factors.

The present attack is in a few regions breaking this complex problem down into its constituent factors, such as the influence of the kind of cover (i.e., whether forest, chaparral, brush, or grass, or combinations of them), of the density of cover, of litter, of the character and rate of precipitation, of the degree of slope, or the kind of soil, or the requirements of transpiration, and is investigating each factor separately. Despite the fact that the latter phase of the work is only 2 or 3 years old, it is already giving extremely significant results, some of which go far beyond what foresters have ever dared to claim. The work on individual factors ought soon to lead to far more productive attacks on small and later on large watersheds than have heretofore been possible. Incidentally there is already specific reason to believe that detailed, exact measurements giving concrete results of the kind which the engineer is trained in and regularly deals with, such as are now coming out of the erosion-stream-flow work, may help materially to bridge the gap which has existed between the points of view of engineers and foresters on the forest-erosion-stream-flow relationship.

The Forest Service has done nothing on wind erosion and dune movement; relatively little on the relationships between forests and snow; has made some progress on purely local influences of shelterbelts in the plains region; and is only beginning to study the possibility of a general amelioration of climatic conditions over large areas.

Possibly one of the most valuable results of our erosion-stream-flow research is that while details are obscure or unknown, it has helped to give to us and to the profession a new and far better appreciation of the probable role of forest and brush and grass, or of the natural vegetative cover, on the whole erosion-stream-flow relationship. It has given a better appreciation of what forest and range deterioration or destruction probably mean in destructive floods, silted streambeds and reservoirs, buried agricultural lands, water in the least usable forms for irrigation, and in reduced productivity of forest and range lands. It has helped to bring out the fact that water may in many instances already, and in many more instances in the future probably will be, the most valuable product of forest and range lands and that every other form of use must be regulated to this end. It has made us realize that this aspect of the forest and range problems in the United States is one of the most important with which we shall have to deal in future managment, and that it is even more important in the formulation of land policies in the broadest sense of the word.

Possibly no other single phase of forest research is at present falling so far short of meeting national needs or offers a greater opportunity for constructive service.

FOREST PRODUCTS

When the Branch of Research was established in 1915 forest products investigations were better organized and financed and are still receiving larger appropriations than any other class in the Forest Service. Since 1910 the work had been centralized primarily in the Forest Products Laboratory at Madison, Wis., in cooperation with the State University, a clear-cut recognition of the organization which would ensure the best correlation of the work and render the largest returns nationally with the resources available.

METHODS OF HARVESTING

The utilization of forest products for most purposes starts with the cutting of the tree and here makes its direct contact with the silviculture that grows the tree. Significant but limited results have been obtained on methods of logging and the principles which underlie these methods, but logging and milling methods are now being investigated directly only in a special study of the small sawmill. The studies in this group have in general considered the use of standard logging and milling machinery and methods in determining the comparative costs of handling different-sized logs and trees of different diameters.

For about 15 species and 10 forest types very complete figures have been obtained on the cost and value of the lumber from trees and logs of different sizes, so that lumbermen and foresters can tell the minimum of tree and log sizes that will "pay their way." The purpose is to encourage, for future growth and the perpetuation of the forest, the leaving of the small trees that can be cut only at a loss.

In naval stores production, utilization begins with the wounding rather than the cutting of the tree. The work to date, which has involved both forest management and forest products investigations, has revolutionized methods of chipping and has given preliminary data on the yield from trees of different diameters, etc. Reference will be made here also to substantial progress on the relation of cell structure to the production of resin, and to the beginning of work on the biochemistry of resin production, although these investigations do not fall logically under the "harvesting" group.

Future work must provide for a considerable extension into other conditions of the determination of the size of the trees and logs which can be cut profitably and of the relationship between cutting for lumber and of utilization for other products, such as naval stores. A broad field, on which only a relatively small start has been made and which should be extended into all of the major conditions throughout the country, is the development of the fundamental principles on which logging methods, including types of machinery, should be based.

Logging methods up to the present time have been developed solely with the idea of getting material out of the woods at the lowest cost and with no reference to the silviculture which will grow new stands. Work along this line will in many cases require the modification of commonly used methods, and in others require the adaptation of existing machinery, if not the development of entirely new machinery.

CONDITIONING FOR USE

The work so far done on the conditioning phase of utilization has consisted largely of the various problems connected with the drying of wood and particularly of lumber. That on kiln drying has progressed far beyond an initial study of different species with standard apparatus and methods. The principles of the kiln-drying process have been developed and applied in improving commercial methods and apparatus to the extent of practically revolutionizing such practices. The fundamental "how and why" of moisture movement in wood during drying have also been studied. Air-seasoning methods and results have been investigated. The work on methods of drying has been supplemented by investigations on allied subjects, such as the change in moisture content of dried lumber during storage and handling, the normal variations of moisture content of wood in houses, and rapid methods, including equipment, for determining moisture content.

A complete understanding of the "how and why" of moisture movement and of moisture relations in general is one of the most important and complex lines of research ahead in forest products and once obtained will have outstanding value in many different ways such, for example, as the further improvement of methods of kiln drying and air seasoning, the development of methods for treating wood which will prevent the absorption of or loss of moisture and hence shrinking, swelling, checking, etc. Similar work will undoubtedly be necessary on modified materials such as pulp and paper, and on some wood products other than lumber.

GRADING AND SELECTION

Lumber grading has been the first crude attempt to select or classify lumber according to value, and obviously value has some relation to properties. Grading has been based entirely on readily visible differences in amount and kind of defects without reference to properties other than those obviously affected by the defects. Except in the rules for structural timbers, the grades have borne no quantitative relationship to any specific property. Forest Service investigations on grading have been devoted partly to the relation between strength and grades in structural timbers, but mostly to the standardization of grading rules for different species, which have varied so widely and have been so complex that they have been very difficult for the public to understand or use.

Selection among species to obtain the best wood for every use is a much more important and complicated technological problem. In fact, it consists of such a large number of separate problems that only a few of them have been investigated directly. General information on the requirements for various uses, together with that on the properties of the different species, must be correlated to obtain proper selection. This subject will be brought up again under "Properties."

It will be apparent that a sound scientific basis is available for lumber grading only in part. The only product other than lumber on which any work has been done by the Forest Service as a basis for grading is on pulps and papers, and such efforts have been confined to the last two or three years. Although lumber is one of the most important forest products, there are others in which there is need for a sound scientific basis for grading.

MODIFICATION OF PROPERTIES

Investigations of methods for the modification of the properties of wood such as durability against decay, fire resistance, and shrinkage, fall in this group. Perhaps, arbitrarily, such allied subjects as painting and gluing are also included. Modification of properties by drying has already been discussed. The logical order of attack is first the application of standard treating materials by standard methods to various species, and then the methods of application; but finally the treating materials themselves, the preservatives, glues, paints, etc., must be investigated and their properties correlated with properties of different wood species and the methods of treatment. The gluing and durability investigations have been in the latter stage for some time; the fire resistance and painting studies have recently reached it. The modification of shrinkage properties has been attacked in two distinct ways, the protection of the wood from moisture by moisture-proof coatings, and the treatment of wood by chemicals that reduce normal shrinkage. The first phase has been very thoroughly investigated; the study of the second is just beginning.

Since modification of properties may have to be so drastic that the original character and form of the wood is lost, it introduces another diversified group of products and hence of investigations. The most important example of this group is pulp and paper. The pulp and paper investigations, which began with tests of the pulp-making and paper-making qualities of practically all important American species under standard pulping processes, have now reached advanced stages of development. Intensive technological studies of the standard processes have now made it possible to increase their efficiency and to modify the processes to fit new species. Entirely new processes have also been developed. In reaching this advanced stage of research, greater refinement of method has been required, more accurate measurement and control, and attention to more details than in the preliminary species studies.

On the possibility of developing other modified forms, such as plastics, only work on a small scale and for a short period has been done. On many more modified products, such as artificial leathers, rayon, etc., nothing has been attempted.

A wide field for research still remains in modifications to prevent the absorption of moisture and hence shrinking and swelling, to develop satisfactory preservatives and treatments to prevent decay under all conditions, to develop economical treatments which will insure fire resistance, etc. In the pulp and paper field there is still room for vast improvement. It should be possible eventually to develop a number of the more common pulps and papers from many common tree species. Possibly ways and means can be developed to reduce excessive wastes in chemical pulping processes which are now responsible for the loss of approximately half of the original volume of the wood. Many agents, such as bacteria, fungi, etc., for the modification of wood have as yet received little or no consideration. Incidentally, it should be possible to work out methods for the prevention of undesirable stream pollution in pulp making.

In modern industry the general tendency which is becoming more and more rapid is to improve the properties of natural materials of all kinds through modification. Materials in their natural state, regardless of intrinsic merit, are facing more and more severe competition from other substances in which properties have been modified and improved, and this in such a way as to meet relatively exacting and varying requirements and specifications. For example, in an article on Steel Takes Research into Partnership, by E. E. Free, published in the December 1931 issue of the Review of Reviews, the following statement is made:

> Dr. John Johnston, director of research of the United States Steel Corporation, recently listed 31 physical and chemical properties of steel which can be altered, more or less at will, by changes in chemical composition, in heat treatment or otherwise, to control the atomic structure of the metal.

Wood in order to hold its own in present-day and future competition must be given the same strategic advantage, and the only reasonable possibility of doing it successfully is by research.

DESIGN AND ADAPTATION

Design and adaptation cover investigations of those uses of wood in which the strength properties are most important. Increase in strength of unit pieces of wood by treatment has not been attempted, but instead the purpose has been by proper design to use at their highest efficiency the intricate normal strength properties of wood. This work of necessity includes not only the wood itself but also the various joints and fastenings by which the pieces of wood are held together, and which are a common and serious source of weakness. The most detailed and complete design work has been done on wooden airplane parts and on boxes and crates; in the latter field the work has already progressed to the final stage of determining the actual strength requirements of wood packages in service. A beginning has been made on house and other structures in the building and construction field. A large amount of investigative work has been done on such joint and fastening accessories as bolts, nails, and glues.

On the fundamental principles which must underlie improved design in building and construction, the field for research is enormous. Applications should be possible which will revolutionize construction both in form and costs and bring back to wood a part at least of the advantages which it has been losing during the last few years in competition with other construction materials. Building and construction, although the largest single consumer of lumber, is only one field requiring work. The availability of modified forms of wood, such as fiber boards, plastics, etc., create additional problems in design.

PROPERTIES

The foregoing groups of investigations consist largely of direct attacks on the practical problems of wood utilization. Investigations for obtaining the basic information required for proper furtherance of the direct attacks may be regarded as falling under the broad heading of "Properties." This group includes not only the determination of the values for the physical and mechanical properties, but also special studies of the chemical composition and structure of wood and of the interrelationships of all these fields. Probably the most complete investigations have been carried out in the field of physical and mechanical properties. The strength properties, specific gravity, and total shrinkage have now been determined for all the important native species, and detailed studies have been made of various factors affecting strength, such as specific gravity, moisture content, and previous conditions of treatment or use. This basic information, together with the technique and experience gained in obtaining it, has been applied in the "Grading and Selection" and "Design and Adaptation" groups of investigations previously mentioned.

The field of chemical composition is much less definite and clear cut, both in its methods of research and in the use of the results. The comparative chemical composition of a number of species has been determined, and some work has been done on relationships between chemical composition and certain physical properties. In the present state of knowledge, however, chemical composition can be stated only in terms of various empirical groups or "constituents" such as cellulose and lignin that are in themselves variable and of only partly known composition. Much of the investigative work on chemical composition is therefore in the stage of developing methods for more completely determining the composition.

The investigations of structure have progressed far beyond the original stage in which the emphasis was placed on microscopic structure as a means of identification of species. Not only have advances been made in the character and detail of microscopic and submicroscopic structure, but the field has been enlarged to include measurements of structure of submicroscopic sizes. Beginnings have also been made in determing the effect of these microscopic and submicroscopic structures on the properites.

Out of a real understanding of the chemical and physical properties of wood may well come some of the most revolutionary changes in the form and character of its future use. What has happened in the coal-tar field as a result of research is one example of the possibilities.

GROWTH CONDITIONS

The effect of growth conditions on wood quality involves both silviculture and utilization. Growth conditions vary so widely and there are so many kinds of wood quality that this is a very broad field of research. Only a few of the simpler and most readily controlled conditions of growth have as yet been studied, and the determination of the effects has been confined largely to the specific gravity of the wood.

The undoubted future trend toward a more and more intensive silviculture, and the increasing intensity of competition between wood and other materials which will tend to make the requirements on wood more and more exacting, will enhance the value of a thorough understanding of the relationship between growing conditions and the character of the final product.

FOREST ECONOMICS

One of the important classes of research in forest economics deals with the forest resource, which consists of such things as the stand of timber, the area of forest land, and the actual and potential growing capacity of the land. Within this field it has been possible since the World War to make three compilations of existing data for the entire country. The results, although largely approximate, have given a clearer conception of the extent of the resource nationally and regionally, and also of some of the sweeping economic changes which are affecting the forest problem with all others. Some data have been collected on the recreation, range, and game aspects of the forest resource, etc., but little on that of watershed protection.

A second important class of economic research deals with national and regional production or consumption of forest products and with requirements for these products. The collection of data on production or consumption has been under way for many years, largely in cooperation with the Bureau of the Census. The data are unequal in character, those on lumber, for example, being much more accurate and frequent than those on fuelwood, a product of importance second only to lumber in drain on the forest. Also constituting a drain on the forest are losses from forest fires on which approximate data have been obtained annually for a number of years, and from forest insects and diseases on which rough data have been compiled occasionally. From time to time also statistics of use by States or other local units have been obtained for most or all classes of forest products, but much less frequently and completely than those on production. Data have also been collected on recreational use, range use, and game production.

A Nation-wide forest survey was inaugurated in the fiscal year 1930. One purpose is to supply much more intensive and authoritative data than have heretofore been available on the forest resource. A second purpose is an intensive study of requirements. Since at the present rate the survey will require at least 10 years more for completion, it is important for many reasons that the work be speeded up. The desirability of keeping the data reasonably current after the work is first completed will be recognized, and this will require practically continuous but relatively small-scale work indefinitely for the entire United States.

Some of the problems of the forest industries are of sufficient public interest to justify investigation by publicly supported investigative organizations and constitute a third class of economic research. Work of this character has included more or less intensive studies of the lumber industry, including its economic status, the distribution of lumber, and various other public aspects, and of the pulp and paper industry, with particular reference to the possibility of obtaining future supplies of pulpwood much more largely or entirely from the United States.

A fourth general class of investigation deals with the economics of forest management and forest land use. Work to date has included a study, still in its early stages, of costs and returns from timber growing, or, in a broader sense, the financial aspects of forestry, in one important region, the South. This is an aspect of forestry on which information is very sketchy and unsatisfactory. Work has also been done on prices and particularly those of standing timber, which are one measure of returns and hence of the incentive to grow timber. Taxation to the timberland owner is a cost, but to the public it is among other things an important source of revenue. Upon the formulation of equitable methods of taxation may depend in considerable degree the extent to which private owners embark upon timber growing. Following some extensive efforts in former years an intensive study of forest taxation for the entire United States has recently been under way.

A closely related group of investigations deals with various other aspects of private forestry—the progress which it has actually made, the determination of the factors which have interfered with its progress, constructive measures for removing obstacles, etc. This work has so far dealt primarily with conditions in the Pacific Northwest, where constructive measures of first importance are being worked out. If they materialize they will revolutionize methods of logging and silviculture and greatly reduce the fire hazard. An intensive investigation of forest insurance has also been started as an aid to timber growing by the private owner. Various studies have been made or started on land questions such as the economic effect of forest devastation in a limited region, and the extent to which a new public domain is being created through land abandonment, etc., together with the formulation of constructive measures for meeting the resulting situation.

The field for investigations which should supply the economic foundation for forest management and forest land use policies is very broad and of critical importance even under normal conditions, but much more so during periods of economic stress. The results of investigations such as those previously indicated, supplemented by other investigations as necessary, should in general determine the proper place of forestry and of forest land use in our local regional and national economic and social structure. The various kinds of work necessary can merely be illustrated, but among others would include: The economic basis for a classification of lands which should be devoted to forestry in contrast with agriculture or other uses; the basis for a classification of forest lands into those which should be utilized for the production of timber for watershed protection, for recreation, etc., or any combination of such uses; the basis for the best distribution of forest land ownership, Federal, State, or other public, and private; the manner and extent to which the public should contribute to or regulate the handling of private forest lands; the best combination of aid and regulation; the basis for sound policies of national forest administration and of lands in other kinds of ownership; and the economic aspects of rotations, cutting cycles, and cutting budgets, or broadly forest regulation. In fact, the field is so broad that practically no other line of investigative effort can be regarded as complete or satisfactory until its economic relationships have been covered.

OBJECTIVES, PAST, PRESENT, AND FUTURE

Whatever progress has been made during recent years in the development of an organization and the facilities for forest research in the Forest Service as well as in actually doing research and obtaining results, is largely due to two things. The first is the formulation of objectives; the second, more or less aggressive and persistent efforts to reach them.

Outstanding among such objectives have been those connected with the establishment of the Branch of Research and those with the passage of the McSweeney-McNary Forest Research Act, both of which are in reality groups of objectives. Underlying these and nearly all other objectives is the recognition of the unity of the complex forest problem and hence of the various classes of research which must be used in its solution.

The most important aspect of the creation of the Branch of Research in 1915 was that it brought the research activities of the Forest Service together and definitely segregated them as a part of a general departmental reorganization which segregated its three main activities. It has been this more than any one thing that has given the first great impetus to research in the Forest Service. It has given to the investigative work and personnel a recognition and standing equal to that of other major Forest Service activities, something which they had not had at least since the transfer of the national forests to the Department of Agriculture in 1905. It has given for the first time the freedom needed for the consideration and handling of research requirements in the special ways necessary to meet investigative needs. It has meant for the first time a national conception of the need for forest research if all forest lands in the United States are to be utilized, of the Federal obligation for a part of this research, and of an aggressive, plan-wise effort to measure up to the Federal obligation. Accordingly, it led almost inevitably among other things to the passage of the Forest Research Act in 1928.

The McSweeney-McNary Forest Research Act formulates objectives in at least three particulars. First, it specifies what research may be done and attempts to cover the entire scope of forest research. Among other things this has made it possible to initiate the Forest Survey and other investigations in forest economics for which it had never before been possible to obtain appropriations. Second, it sets up a program of field units based upon such fundamental considerations as the interrelationship and unity of all phases of the forest problem and hence the necessity for well-rounded-out group attacks. This gives full legal sanction to the Forest Products Laboratory and the forest experiment stations already established, sets up authorizations for other stations known to be needed, and incidentally prevents the establishment of unneeded stations. Third, it outlines a 10-year financial program with restrictions as to total appropriations, which takes into account not only the national needs for research but the rate at which an efficient organization can be built up. The restrictions lapse at the end of the 10-year period and whatever appropriations may subsequently be necessary in the public interest are authorized. This act has been directly responsible for the first time in the history of forestry in the United States for appropriation increases even approximating national needs.

The background had been prepared by the work of the previous years for many of the remaining objectives which have contributed to the development and progress of research. But the clarification of nearly all of these objectives has resulted directly or indirectly from the two outstanding groups connected with the establishment of the Branch of Research and the passage of the McSweeney-McNary Act.

Among the remaining objectives are working facilities necessary for the most efficient conduct of research, such as experimental forests and ranges, the setting aside of which is now for the first time moving forward satisfactorily; laboratories, of which the new Forest Products Laboratory Building is outstanding; and the headquarters for field units which will be most effective in stimulating the development of the investigative staff, with 7 out of 12 such headquarters now maintained in close cooperation with educational institutions. Among them are also the highest possible standards for recruiting, which are bringing into the Research organization a group of the most promising men obtainable in the American forestry profession and which also are playing an important part in stimulating the training of men for research and the development of forest schools to give this training.

The annual programs required of all the Research units are nothing more than objectives for a year's work consciously designed to concentrate attacks on the problems which are most important and urgent from the public standpoint and to insure continuity of purpose. The policy of organized rather than individual attack on the problems selected is merely one means to the most effective carrying out of objectives. Written plans on each phase of the work or project are objectives for the investigative attack itself.

The unity of the complex forest problem and the interrelationship of all of its phases which run through and underlie most if not all of these objectives have been recognized by the establishment of the Branch of Research, which brought scattered investigative activities together; by the Forest Research Act, which treated these activities as phases of a closely related whole; in the fundamental principles of organization of the forest experiment stations, which brought groups of these activities together for specific forest regions; and in the principles of organization of the Forest Products Laboratory which brought together activities in its particular national field. They have been recognized in special provisions for coordination of effort in the twilight zone between forest management, forest range, and erosion streamflow; in forest products investigations; in the Forest Survey and other investigations in forest economics; in the coordination of effort in all classes of research by means of annual programs for each field unit, and in well-rounded-out group attacks rather than individual effort. The ways in which this unity must be recognized grow constantly. Recognition of it is one of the outstanding lessons of past work and consequently an objective which must be taken into account in all future plans.

The value of objectives should not be judged solely from progress in developing an organization and facilities for research in the Forest Service, because they are merely means to an end. A more important objective than either is the research itself, and a still more important objective is results which will aid and stimulate the development of forestry. But research results themselves are only a means to a end. The ultimate objective is the actual use of the results for human benefit. While investigators have a real but incidental responsibility for getting their results into use, the final responsibility rests on others, on the owners and managers of forest lands, and on the stockholders and executives in forest industries.

The investigative findings on practical methods of both natural and artificial regeneration of forests, on the life histories and requirements of trees and types, on volumes and yields, and on the control of forest fires have added to the assurance and certainty of efforts made to grow, protect, and manage timber. So far, the publicly owned national forests are the chief beneficiaries from the application of these results, but here and there also is a private owner. On the national forests application is at its best in fire control, for example, and follows research findings even before these have been recorded in progress report form, and in some instances the same is true of silvicultural methods.

The main contributions of forest range investigations, knowledge of the range plants and of their growth habits and forage values, the determination of a few important principles of range management, and, finally, the relationships between range use and forest regeneration, have also found their main application in national forest administration. Improvements in herding and bedding methods for handling sheep have, however, been rather generally adopted by the livestock industry on other ranges.

By far the largest application of the rather meager but significant findings to date on the indirect influences of forest and other forms of wild vegetative cover has also been on the national forests and for the use of forest or other cover as a means for controlling erosion or regulating stream flow by many municipalities and here and there a private corporation. The findings have to some extent been responsible for efforts toward sounder policies for other forest and public domain administration.

In the forest-products field, progress has been greater and more diversified mainly because larger funds have been available. The benefits from application in the forest industries, which have been very large, soon reach the ultimate consumer at one extreme and the owner of forest land at the other. And the public which owns the National and State forests is by far the largest single owner. Kiln drying of lumber has been revolutionized, as has also preservative treatment of wood against decay, the technique of naval-stores extraction, and wood-container design. Large numbers of pulp and paper mills are using improved pulping processes, several new mills have been built to utilize new processes, and the number of species in common use is gradually being extended.

The data on strength properties for nearly all American species and the factors, such as moisture, which govern them have been determined and are being rather generally applied. A scientific basis for the grading of structural timbers has been adopted for a limited number of species, and worth-while contributions have been made to the standardization and simplification of lumber grading. Principles of design in houses and other forms of building construction and in joints and fastenings have been less fully worked out and much less widely applied than those for containers.

Results which have not yet gone far enough for extensive application include the breaking down of wood into component groups such as cellulose; the microscopic and submicroscopic study of structure and the relation of structure to properties, and studies of the relation of growth conditions to specific gravity and hence to strength.

The economic data obtained in the three extensive forest surveys of the entire United States and other economic studies are more or less widely used as a background in the formulation of forest policies, National, State, and otherwise, and also in attacks on them. The conclusions in extensive studies of forest taxation, which preceded by several years the intensive study now in process, are reflected in many State laws.

Since the major part of the development of research in the Forest Service has come since the war and chiefly during 1930–32 much of the work has been under way too short a time to produce results. For much of this uncompleted work the value of setting up and working toward objectives can only be judged in the future.

The reader is perhaps in a better position than those who have been engaged in the effort, to judge whether the progress made in the development of an organization and facilities for forest research has been worth while. He is also perhaps in a better position to judge whether the progress in research itself has been worth while, but must give full recognition to the fact that what has been done constitutes only the barest kind of a beginning. Finally, he is in a better position to judge whether the progress in the application of results has been worth while, although it must be recognized that application almost inevitably lags behind the knowledge available.

If the verdict is that worth-while progress has been made, the formulation of objectives and efforts to reach these objectives have justified themselves; and the most important of these objectives, the plan of bringing together and of segregating investigative activities, which was the essence of the creation of the Branch of Research, has justified itself. So also have the efforts which led to the formulation and passage of the McSweeney-McNary Forest Research Act, and the recognition of the unity of the complex forest problem and hence of the different classes of research which must be used for its solution. If worth-while progress has been made, one of the chief lessons of the past is, therefore, the value of objectives and of steadfast, persistent efforts to reach them.

A severe economic depression is possibly sufficient justification for caution in announcing if not in making far-reaching plans for formulating additional objectives. If the use of all of our land in the United States and the development of all of our industry had been plan-wise, however, we might have escaped the present depression. A possible means of minimizing if not eliminating future depressions may lie in the right kind of planning. The making of plans or the setting up of objectives for the future is in a real sense an expression of faith in the future of the United States and of preparation for it. The creed of the forester and the very nature of forestry require the long look ahead and in themselves justify the setting up of far-reaching objectives. All of these things apply in research as much as in any other phase of forestry—and to research with particular force if the progress of the last decade and a half and the reasons for it have been correctly interpreted.

Five years' experience has shown some deficiencies in the McSweeney- cNary Forest Research Act. Forest influences now demand a recognition which probably could not have been obtained when the act was passed in 1928. A bill introduced in the Seventy-second Congress adds a new section which rounds out the original provisions by providing more specifically for erosion-streamflow investigations on forest and range and other wild lands, and puts this work on its own feet as to legislative authority and financial plan. By providing for the work at the forest experiment stations full correlation with related classes of forest research and lowest costs are insured.

Justification for this legislation lies in part in the growing importance of flood control in the United States. Major flood catastrophes are ordinarily taken into account only as detached occurrences and are soon forgotten. Lesser floods are often ignored and never considered in the aggregate. The flood situation of the United States is, therefore, far more serious and the necessity for control far more important than is generally realized.

Justification lies also in part in erosion losses which threaten to make man-made deserts of an enormous area of land and threaten seriously to reduce the productivity of another enormous area. Much of the process is so insidious and so inconspicuous that little realization exists nationally or even locally of what is going on and what it means.

Justification for this legislation lies in part in the fact that water for agricultural, muncipal, power, and other uses is both the key to and the limiting factor in the development of the West. Recognition of the growing need for municipal supplies shows that water is also one of the most important factors in maintaining the development of the East.

Justification lies also in wide differences of opinion as to whether forest and other cover is a decisive factor in erosion and the regulation of stream flow. These differences range from flat rejection, through theoretical but passive acceptance, to full acceptance handicapped in detailed application to forest and range management by lack of knowledge. These differences are reflected in public demands as divergent as for the total destruction of the forest or chaparral or range cover, or its full protection against fire, cutting, and grazing. They are reflected in radically different policies or the entire lack of policies in the administration of public and private lands with watershed values. They are reflected in expenditures of hundreds of millions of dollars for flood control, the improvement of navigation, dams, and for municipal water supplies in which the possibilities of such influences are disregarded or variously recognized. In the last analysis these differences in opinion, demands, and action reflect the lack of knowledge which the proposed legislation is designed to supply up to the limit of Federal obligations. The existing watershed conditions in the United States which justify the enactment of this legislation are described in detail in another section of the report on Senate Resolution 175.

The provision for the Forest Survey in the McSweeney Act is probably the best that could have been obtained in 1928. The limitation of annual expenditures to $250,000 drastically limits the rate of progress and inevitably extends the period required for completion. One unfortunate result will be the obsolescence of data for one region before it can be obtained for others. Furthermore, uncertainties and wide differences of opinion on forest policy continually emphasize the need for information which the Forest Survey is obtaining. In nearly every important forest region of the United States the depression has brought to light serious problems for the lasting solution of which the Survey alone can furnish the necessary information. A modification of the Research Act is therefore justified in order to speed up the initial survey. Under the existing legislation the work must be discontinued as soon as the initial survey is completed. But it is becoming more and more clear that provision should be made for keeping the data current indefinitely. These considerations will soon justify another amendment to the Forest Research Act.

Closely related to the Forest Survey is another problem, land classification, the crucial importance of which as a great national enterprise is beginning to be appreciated only during the last few years largely as a result of the efforts of the Bureau of Agricultural Economics. Various classification activities have been under way for many years, such as the soil survey of the Bureau of Chemistry and Soils, and the classification of forest and agricultural lands in the national forests by the Forest Service.

Agricultural as well as and possibly more than forest land is involved in the national classification enterprise. The need for classification is indicated by maladjustments in land use which are particularly apparent during periods of economic stress such as the present. The evidences include widespread abandonment of agricultural lands, particularly of the submarginal class, often with tragic consequences to the owners; the breakdown of town and county governments which is one extreme local result of the nonpayment of taxes and land abandonment; an unregulated back-to-the-land movement growing out of unemployment, which in some instances promises to repeat the vicious cycle of attempts to use lands unsuitable for agriculture followed by later abandonment; and excessive erosion and disastrous floods following the cultivation of lands which should have been kept in forest. The information obtained in the Forest Survey, that obtained in other economic investigations, and also that obtained in forest management investigations, will necessarily have to be supplemented for the intelligent classification of forest lands. Integration of all pertinent information on the character of the land itself, what it can be expected to produce, and related economic and social questions must be insured in order to furnish satisfactory results.

Provision for Forest Service participation in the forest-land aspects of classification can be made either in an additional section to the McSweeney-McNary Act or as a part of a general authorization for all classes of lands. What funds will be needed is uncertain, because no attempt has been made as yet to work out detailed plans. As an approximation, however, it would be well to provide for annual increases of some such amount as $50,000 or $75,000 over a period of as many years as may prove necessary, which might reach five.

Substantial progress, particularly under the stimulus of the McSweeney Act, has been made in financing new research. Even though the depression does not force serious cuts in appropriations, and the authorization limits are reached in the fiscal year 1938, it is becoming more and more clear that by that time only a substantial beginning can be made toward covering the field necessary to meet Federal obligations.

In the Central Rocky Mountains, work is now confined to a small part of the silvicultural field and the experiment station is little more than a name. Outside of the United States proper no attempt has been made to establish the stations authorized for Alaska, Hawaii, or the West Indies. With present resources no silvicultural work can be done on many of the important forest types in the forest regions in which experiment stations have already been established. On no single forest type is the present attack adequate. In only three regions is a sizeable attack on the forest-fire problem under way, and even in these it falls far short of what would be desirable.

In the important field of forest regulation no investigative work is now being done, as has already been indicated. There is a very distinct possibility of worth-while research contributions to forest engineering. Very little has as yet been attempted in the broad and promising field of forest genetics. Shade tree and park forestry is still another broad field which is hardly being touched, despite its place in the public interest.

Forest range investigations are confined to four western regions, in two of which work has been started only during the fiscal year 1932. In all of the remaining western regions the field is practically untouched. The range problem is also important in at least two eastern regions, the Middle West and the South. The southern problem, particularly that in longleaf pine, is triangular, involving range use and timber growing, and the relationship of fire to both. The possibilities of artificial reseeding of ranges and of the development through plant breeding of improved forage plants are being largely or altogether neglected.

Many additional experimental forests and ranges must be established to carry out the silvicultural, range, and erosion-stream flow investigations indicated, and all will require funds. In fact, with the funds now available it is not possible satisfactorily to handle the experimental areas already selected.

Economic problems growing out of changing conditions in forest and agricultural land use, in the possibilities of growing timber and other forest crops, and in the forest industries are, particularly during this period of financial stress, appearing far more rapidly than they can be solved. Long-established foundations are being swept away and what is to take their place is being left entirely to the play of blind forces. Other groups of problems which have important economic aspects arise out of the administration of large holdings of forest lands such, for example, as the national forests, and include forest regulation. The economic and sociological importance of forests in recreation is increasing rapidly as a result of such things as the automobile, good roads, and a large increase in leisure for practically all classes of people.

Forest products are falling behind in the competition with other materials because for one thing less is known of their properties and how to use them. It is conceivable that forest products research can be made one of the chief competitive weapons to maintain and increase consumption, and hence of an aggressive, constructive, plan-wise effort to make certain the use of forest land, and to keep available for public use a material of high intrinsic value. The indications are many that the time has come when such aggressive efforts are absolutely essential to insure full and satisfactory forest-land use. The effort of the Federal Government to maintain and enlarge the consumption of forest products is confined to forest products investigations. It is now and has always been seriously out of balance with the effort to grow timber.

A greatly enlarged scale of work in practically the entire utilization field is called for with particular emphasis on the chemical and physical and other properties of wood on the most intelligent selection or use of wood in the light of these properties, on how to modify and adapt the properties for particular uses, and on the development of better design and assembly methods in building and construction which consumes over 60 percent of the lumber produced in the United States.

With work ahead of the magnitude and scope indicated, it is necessary upon the completion in 1938 of the 10-year period provided under the research act to look forward either to taking advantage of the lapse of the specified appropriation limitations, or to legislation for an entirely new financial plan. In either case, economic conditions permitting, regular increases should continue as fast as competent personnel can be obtained, until public needs and Federal obligations are met. Some classes of work can contribute so directly to the solution of acute depression problems that serious consideration of appropriation increases as emergency measures is justified. Among these are the Forest Survey and some other forest economic investigations, and various phases of the utilization problem. National losses from excessive erosion and unnecessary floods are already so great and the threat of still worse conditions so serious that special consideration is also justified for investigations of the use of forest cover for control. Belief that the amounts needed for emergency and for regular subsequent increases can and will be made available is merely an expression of confidence in the future of the United States. It is quite possible that experience may show the need for more additional sections of the act than have been indicated in order to provide satisfactorily for the work discussed.

Prospective financial needs for the decade beginning 1935 are forecast in the following tabulation. The first column of figures indicates the average annual increases needed for the various classes of forest research to carry out the financial plan prescribed by the McSweeney Act for its last four years, and also to provide for erosion-streamflow and land classification investigations. If, as now seems practically certain, economic conditions will prevent all but extreme emergency increases in 1934, the average for the four remaining years of the act will be correspondingly higher. The second column of figures indicates the average annual increases needed for the last six years of the decade:

Average annual appropriation increase

Appropriation item	Fiscal years 1935–38	Fiscal years 1939–44
	Dollars	*Dollars*
Forest management	115,000	100,000
Range investigations	40,000	50,000
Forest products	110,000	100,000
Forest Survey	(80,000)	----------
Forest economics	45,000	25,000
Erosion-streamflow	100,000	40,000
Forest land classification	50,000–75,000	----------

The amount specified under the Forest Survey is that required to raise the appropriation to the existing authorization of $250,000 in a single year. The research act should be amended to increase the maximum annual authorization to $500,000 for the initial forest survey. The increase of the appropriation to the higher authorization should not be extended over three years as a maximum. Provision should also be made for continuing the work necessary to keep data current after the completion of the first survey, and this may require a regular appropriation of approximately $200,000 per year indefinitely, although the work might perhaps be done for less. The amount specified in the second column for erosion-streamflow investigation is that needed under the provisions of the proposed Leavitt amendment to the McSweeney-McNary Act.

The future trend of the work is almost certain, judging from past experience, to be from the extensive to the intensive, and from the general or exploratory to the fundamental. The easier and more obvious problems are gradually covered and a working basis of fairly satisfactory results furnished for current use, releasing men and resources for more intensive attack. The solution of the easier, more superficial problems and the growing intensity of actual practice leads inevitably to the fundamental how and why of biological phenomena, on the answer to which must depend fully satisfactory practice. Work over a period of years is bound to give a much clearer conception of what the underlying or key problem actually are and to emphasize the need for work on them. Men with the requisite training and experience are gradually developed or become available. Industrial concerns in such fields as forest products are gradually stimulated to undertake for themselves some of the simpler or application problems, thereby releasing the Federal investigative staff for the more difficult time-consuming fundamental work. This also promises to be true of the administrative force on the national forests in such problems as timber growing and protection, range management, etc.

Practically every consideration, therefore, emphasizes a gradual trend to more and more intensive attacks in all phases of forest research; and this makes adequate provision for working facilities, such as experimental forests and ranges, all the more necessary. The adoption of clear-cut objectives for such experimental forests and ranges within the past two years has materially speeded up their selection, which had previously been very slow. The number will have to be gradually but substantially increased. Energetic efforts will be necessary to insure the setting aside of some of the areas needed before they are seriously injured or ruined for experimental purposes by the cutting of the timber or other forms of use. These areas, particularly when they have a background of several or many years' work on many phases of the forestry problem, will offer ideal and in fact indispensable facilities for intensive work on fundamental problems. At the same time their value as demonstration areas will increase. Large numbers of investigations will be under way on contiguous areas, and integrated with them will be intensive studies to determine the why and wherefore of all that happens. Natural areas must also be set aside in advance of the ax and the saw.

The corresponding problem for forest products investigations will be simpler because of the recently completed laboratory at Madison, which will meet major needs for working facilities for some time to come.

Like all other publicly supported organizations, the Forest Service is dependent upon publications as one of the chief means for making its results known. One of the great needs, not as yet satisfactorily met, is to publish results promptly so that the development of forestry will be stimulated as much as possible. What this calls for perhaps most of all is a medium of publication which will handle progress reports as they are completed. A progress report series, the numbers of which can be issued periodically or whenever the amount of material warrants, would go a long way in meeting the situation. It would undoubtedly have important incidental results in helping to maintain a high morale in the Research organization, particularly if investigators can be placed largely on their own responsibility for the material published.

Competent, well-trained men will probably continue to be the limiting factor in the development of most classes of forest research for some years to come, if economic conditions permit the expansion indicated in the preceding discussion. Efforts to maintain the highest standards possible in recruiting should be continued. Standards should in fact be raised as rapidly as this can be done. Every possible effort must be continued to stimulate the training of men before they are employed, and when it is necessary to take on men not fully trained, every possible means for developing them on the job and for allowing them ample opportunity to supplement their training at the universities must be utilized. The character of work done and, within limits, its amount will in the last analysis depend more upon the qualifications of the staff than on any other one thing.

It has not been possible to keep the growth of the Washington overhead of the Branch of Research in suitable ratio to that of the field staff. The result is that in this particular respect the development of forest research is probably more seriously handicapped than any other research in the Department of Agriculture. This is true both of number of men and their compensation. The fact that the work is in an entirely new field and that the training of personnel and the development of an organization are still in an early initial stage makes the need all the more urgent. As soon as the economic situation permits, this requirement should be met.

Many things on which a Federal forest research organization can and should render a large public service lie outside of the ordinary research projects and even outside of the ordinary research program. Periodically, for example, the need arises for the synthesis of results from many different lines of work in order to meet some exceptional public requirement or even some public emergency. Such a need now exists because of sweeping economic, industrial, and social changes, the ultimate outcome of which no one can foresee, but the importance of which no one denies. Because of these changes, much that has been accepted in the past in forestry, along with everything else, is now subject to uncertainty or attack. Some of the questions which are being raised regarding the present status and the future of forestry are unquestionably sincere. Others undoubtedly should be raised and must be faced. Others are undoubtedly intended to relieve private owners and industries of any and all responsibility for any contribution to future timber supplies, and tend to undermine the whole forestry movement. Some of these attacks are undoubtedly a part of the sincere and perfectly legitimate effort of overburdened taxpayers to eliminate unnecessary governmental functions or to reduce their cost. The purpose of other attacks seems, however, to be to restrict the scope of governmental activities, to weaken the power and authority of government, and to relieve industry of public control.

One of the results is the unsettling of old objectives and the growing of a defeatist attitude concerning the possibilities and even the need for forestry. Another is that the attacks are beginning here and there to affect the development of forestry by the Federal Government, by States, and by private owners in such critical ways as appropriations or financial support.

Such situations as this call for an exceptionally broad and comprehensive handling. They call for a searching analysis of all the facts that can be obtained. They call for a reexamination of the public advantages of productive as contrasted with idle forest land. They call for a restatement of the whole forestry problem, of the program necessary for its solution, and of the Federal, State, and other public and private opportunities for the solution. All of this should help to clarify the atmosphere and, so far as may be necessary, to reorient the whole forestry movement. It should furnish the basis for constructive action along particularly broad and aggressive lines in order to insure the profitable use of forest land. It is nothing more nor less that this report on Senate Resolution 175 attempts to do, and for which the resolution affords the opportunity.

This is only one illustration of the big, far-reaching contributions which are periodically needed in such an enterprise as forestry, if it is to be kept an aggressively constructive and vital force in American social and economic welfare, and if the Federal and State Forest Services are to have the objectives which are absolutely essential to keep them as fighting organizations for the public interest. Contributions such as this must, however, be based on research technique, and the responsibility for them rests primarily upon forest research organizations, Federal and otherwise.

THE PROGRESS OF FOREST PATHOLOGY

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INTRODUCTION

Among the diseases are included not only those caused by fungi, bacteria, mistletoes, and other types of parasitic plants, but also the unhealthy conditions resulting from such causes as frost, excessive heat, and poisonous gases. Some of the effects of drought, wind, fire, and mechanical injuries are sufficiently like those of parasites or have such an influence on the course of the parasitic diseases that for practical purposes they are also classed among the diseases. Insect injury is considered elsewhere, though there are some cases in which the insects and plant parasites work in such close partnership that they cannot be entirely separated.

Diseases affect forest productiveness in three ways—by killing trees, by slowing down tree growth, and by degrading or destroying the wood after it is grown. Reliable loss figures are available for only a single kind of damage, i.e., decay of wood that has already grown, and even for decay they are available for only a few of our forest-tree species. Diseases sometimes lower the value of the forest for recreational use by rendering it unsightly and occasionally hurt its effectiveness in watershed protection. Direct control measures are being applied on a considerable scale only in forest nurseries and against blister rust in the white-pine forests.

FOREST DETERIORATION BY NATIVE DISEASES

DISEASES AFFECTING NURSERIES

There are a number of diseases that have caused serious loss in nursery stock in the past. The obvious result has been unnecessarily high cost of planting stock at the nurseries where disease has been most prevalent. Even a very moderate increase in plantation cost after interest charges have accumulated on it for half a century may make the difference between profit and loss on the plantation. At many nurseries there are occasional disease epidemics which practically destroy entire blocks of beds and introduce a troublesome uncertainty into the raising of planting stock and in planting programs. Because this uncertainty feature is one of the most serious effects of nursery diseases, and since its effect cannot be expressed in dollars and cents, no quantitative estimate of the total loss due to disease can be made. Another consequence of diseases in the nursery which is hard to evaluate, but which may prove more important than all others, is the introduction of disease into new plantations on the planting stock.

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[1] Especially S. B. Detwiler, E. P. Meinecke, W. W. Wagener, R. K. Beattie, and Lake S. Gill.

Some of the heaviest losses have been due to nonparasitic diseases, particularly drought, excessive heat of the soil surface, frost and winterkilling, and from unwise use of mulches or fertilizers. All of these are reasonably easy to prevent when recognized, and prove troublesome chiefly because they are often confused with parasitic diseases. Education and increasing experience of the nurserymen have already resulted in reducing loss from these sources, and they should not be serious in the future.

Diseases due to parasitic fungi include the "damping off" of very young seedlings, root rot of older stock, needle diseases, molds that work under snow cover, and the stem rusts of pines. Damping off has been found to yield to inexpensive methods of soil disinfection or acidification in most places, needle diseases and fungi under snow can be prevented by spraying and supplementary practices, and rust infections can be minimized by eliminating infection sources from the vicinity. Root rots are the only major group of nursery diseases for which no reasonably effective control methods are known. A number of alternative treatments are available for trial on nursery diseases which would be too expensive for use in field plantations or natural reproduction. Some diseases will probably always be found too difficult or too expensive to control at all nurseries or on all tree species; but the nursery industry requires relatively little ground, and at the worst it can hunt for sites on which a susceptible species is found least subject to infection. The development of a new treatment or the finding of the best nursery site for raising a particular species usually requires years of experimentation, but if adequate research is maintained, reforestation plans need not be retarded for fear of diseases of conifers in the nurseries, at least so far as native diseases are concerned. With hardwoods there has been less experience, but no disease is expected for which a few years of investigation would not develop satisfactory control on the more favorable nursery sites.

DISEASES AFFECTING PLANTATIONS

Diseases in plantations have been less studied than in nurseries. Plantations, if on properly chosen sites, ordinarily suffer less from disease during their first few years than do nurseries. There are, however, exceptions to this rule among the diseases already studied. For example, the brown-spot needle disease in the longleaf pine of the Gulf States becomes important very early, even in well-placed plantations. In much of the longleaf region this disease attacks the trees during the first few years after planting and so weakens them that they require several more years to start height growth than do the uninfected trees, and many of them die. Spraying with fungicides during the first two or three years, and in some cases the use of fire in preparing planting sites, are expected on the basis of studies now in progress to minimize the losses from this disease at a cost that would be more than counterbalanced by the decreased length of time required for the establishment of the plantation; but with the best success that can be expected this disease will continue to be something of a handicap in the reforestation of the large areas of denuded longleaf land in the South. Another disease of young plantations which can be only partially avoided by any methods at present known is the Phacidium blight of spruce and fir in the Northeast, which destroys trees that are small enough to be buried in snow.

Where sites are obviously not properly adapted to the species or are chosen without reference to disease hazards, plantations may be badly injured by disease in early life. For example, Douglas fir is seriously damaged if planted where late spring frosts are frequent. Conifer plantations should not be located on land where certain parasites are present in quantity unless it first proves practicable to destroy the sources of infection. This rule holds for the dwarf mistletoes of pine and Douglas fir in the West, and for stem rusts that easily attack ponderosa pine, loblolly pine, and other species of both East and West. In reforesting sites in parts of the industrial region of the Northeast, species particularly susceptible to injury or growth reduction by smoke or sulphur dioxide should not be employed.

In general plantations continue healthy till they reach the sapling or pole stage, but some of them begin to deteriorate after that time. Even trees that are not overcrowded may stagnate, or become deformed, or perhaps die. Such failures in plantations that had started well are little understood. Part of them appear to be due to root diseases, which are enabled to attack the trees as the result of too deep planting, unfavorable soil, the use of pure stands of a single species, or the use of stock grown from seed collected in habitats different from that in which the planting is made. All types of parasitic disease, but especially the root rots, are favored by growing large numbers of the same species of plant in pure stand. Pure stands are relatively rare in nature, and their use in plantations undoubtedly accounts for some of the disease liability. No one knows enough about soil factors to be certain what sites will grow healthy plantations of any particular species, and most plantations are of necessity placed on old fields where soil conditions are no longer normal for forest growth. There is particular need to correlate soil studies with studies of plantation diseases. While root troubles are difficult and expensive subjects for investigation, it is highly desirable that unsatisfactory plantations should be subjected to intensive root study by pathologists.

Most of our forest species have practically all of their finer absorbing roots infected with mycorrhiza fungi, so that their absorption of moisture and minerals from the soil must be through layers of symbiotic fungi. Some students of the mycorrhiza have regarded them as beneficial to the tree, while others consider them harmful. There is every reason to believe that some of the species of mycorrhiza fungi are harmful to particular tree species or under some kinds of conditions, and that some of the plantation difficulties may be due to them. The subject has been found by early investigators to be one of extraordinary difficulty. Systematic studies have been undertaken recently in this country, and it is hoped that some of the points in question may be cleared up. There seems to be no hope of preventing the development of mycorrhiza, even if it were proven desirable to do so. There is, however, a possibility that when our knowledge of these fungus-root structures becomes more adequate we can influence the success of a plantation by seeing that the right species of mycorrhiza fungi get possession of its roots before the trees leave the nursery.

In this connection special mention should be made of the disease situation resulting from the use of exotic tree species in forest plantations. A considerable number of foreign trees are being tried in a small way by our forest planters, and Scotch pine and Norway spruce are grown to a considerable extent in the Northeast. Exotics can be advantageously planted for special local wants; for example, to produce hardwoods on the Pacific coast, to produce chemicals, as tannin or heptane, or to supply timber that is more resistant to termites and decay than the local species. As native species are eliminated by introduced diseases or insects, we will have increased need for trial of exotics. One case of introduction of exotics to replace a lost species has already appeared in the Asiatic chestnut species which are being introduced in quantity in the hope of getting a satisfactory replacement of the American chestnut; these, although resistant to chestnut blight, are already being attacked by several of our native fungi. It is true that in migrating to a new home, a tree species sometimes escapes from parasites which have reduced its usefulness in its native range, and makes better growth in the new habitat than it did in the country of origin; but most exotics are not so fortunate. An introduced tree is very likely to find in our rich fungous flora at least one parasite to which it will lack resistance. Such a fungus may be rare or geographically limited at first, and cause no serious trouble to isolated test plantings; but if the exotic tree becomes widely used, the troublesome fungus can multiply and extend, slowly at first and with gradually increasing speed, till at the end of one or two generations of extensive use of the new tree its early promise may entirely disappear. This is exactly what happened to our American white pine when it was used in Europe. It was adopted by British and Continental tree planters with great initial success. Rapid growth and high quality in early trials resulted in extensive planting. Now, after half a century of additional experience, white pine is being abandoned over a large part of the countries in which it was once popular. The ultimate failure is entirely due to a rust fungus, previously rare in Europe, which found a congenial host in the introduced species and gradually became more widespread and abundant till it became a controlling factor. Scotch pine, the exotic which we have most employed in the United States, and which seemed for the first few decades to be quite free from enemies, is now being attacked to an alarming extent in Pennsylvania, New York, and New Jersey by at least three diseases, the sweetfern rust, the Woodgate rust, and the other of yet undetermined cause.

As has been pointed out, much of the pathological condition of plantings of native species in the past appears to be due to the use of seed from distant sources and different climates, rendering the native tree species essentially an exotic in the locality where it is planted. For example, Norway pine from northern Minnesota seed cannot be expected to be normally resistant to parasites if it is planted in the Middle Atlantic States. A native tree may even be planted entirely outside of the natural range of the species; for example, northern white pine is planted in Ohio and Indiana where despite good initial growth plantations have suffered severe losses from an obscure wilt disease. This practice of use of seed from a distance is always likely to be followed to a certain extent, because of the difficulties in obtaining seed of some species just when and where it is wanted, but is fortunately becoming less common as the foresters recognize its danger. Another factor must, however, be considered in estimates of disease susceptibility of future plantations. Forest geneticists are beginning to select particularly desirable types from our timber species and even to breed them. In poplars planted for pulp, vegetatively propagated varieties will probably be in common use in the not distant future. This means that strains of fungi very specially adapted to the particular strain of the tree species that is being used will have an unprecedented opportunity to spread. In a promising attempt begun some years ago by a paper company to utilize fertile overflow land in Ohio by growing the so-called "Norway poplar", a uniform fast-growing variety, the tree had to be abandoned because of a branch canker disease which overran the plantings after they had been under way for a period long enough to let the specialized parasite multiply. While the forest-tree breeder will select his types from those that appear resistant to the more important diseases, it will be very difficult to insure resistance to all the species and strains of fungi concerned, and this will be particularly true for the soil-inhabiting fungi. We have some reason to fear that progress in forest genetics, if or where it goes far enough to give us planted forests of selected strains, may conceivably put our forest plantations into somewhat the same condition of disease susceptibility that we already see in our orchards. This is particularly likely unless study of diseases and development of methods for testing resistance proceed more rapidly for the species to which the geneticists give their attention. On the whole, more trouble is expected from disease in plantations than in nurseries or in young stands arising by natural regeneration. Because of its cost, there is little chance for direct control of diseases in field plantings. This means that we must not only learn to distinguish the different diseases, but particularly for the root diseases we must know their means of spread and their relation to soil conditions, stand density, species mixture, kind of mycorrhiza, and every other factor through which the activity of the parasite or the resistance of the host may be indirectly influenced either in choosing plantation sites or in making and managing the plantations. Unless the present information on these subjects is rapidly increased, it is to be expected that there will continue to be disappointing results in some of the new plantations due to injury by native disease organisms.

DISEASES AFFECTING IMMATURE FORESTS

Forest stands throughout their life are subject to unfavorable influences which reduce their productive capacity, either by a reduction in the rate of growth or by adverse changes in the density of stocking. Fully stocked stands are exceptions rather than the rule in this country. For example, in the Pacific Northwest the average stand of immature Douglas fir is stocked from only 82 to 83 percent of board-foot capacity, while for other species in other regions the percentage of understocking seems generally higher. Although the character of this loss is apparent, its exact evaluation is difficult, and it is particularly hard to accurately gage the effect of each of the causal factors of this understocking when more than one is operative, as is usually the case. However, parasitic fungi and dwarf mistletoes of conifers play an important part in reducing yield, both by killing trees, thus causing understocking, and by lessening growth rate, thus requiring a longer time to produce a given quantity of timber. Diseases of the foliage, while rarely causing the death of enough trees to affect stocking, by killing many leaves do interfere with food production to such an extent that rate of growth is reduced. A particularly notable case is the brown-spot needle disease of longleaf pine already mentioned in connection with plantations, which so weakens young trees in natural reproduction in parts of the South that it not only adds a number of years to the time required to grow merchantable timber but on the poorer sites it may kill so many seedlings as to entirely prevent the development of a properly stocked stand. Root rots and stem-inhabiting fungi, particularly rusts, also kill many young trees. These parasites rarely become suddenly epidemic in such a way as to kill trees over extensive areas in a short time; they more commonly take a steady annual toll from infected stands. Here again if the productive capacity of the stand is not reduced, the losses are of no consequence, but if enough trees are killed either to cause understocking or in addition in a mixed stand partial elimination of the more valuable species, then significant damage results.

The most serious diseases reducing growth rate and also killing trees outright are those caused by dwarf mistletoes of conifers. These dwarf mistletoes are very different from the holiday mistletoe known in the East; they have no leaves and are without any sentimental or esthetic value. In the West there are few conifers free from their attack. The valuable stands of ponderosa pine in particular suffer severely. Over extensive areas throughout the range of this pine many trees are so deformed as to be worthless, some are killed, and many more are infected sufficiently so that their rate of growth is considerably lessened. A normally stocked stand of 40-to-50-year-old ponderosa pine in northern California, moderately infected with dwarf mistletoe, was found to have one third of the trees infected and 14 percent ruined by stem infections. On another area where the attack was heavier every tree was infected and over 80 percent were ruined by stem infections. In northern Arizona the average volume increment over a 5-year period was found to be 4.53 cubic feet for healthy trees and 2.23 cubic feet for heavily infected trees. Stands of ponderosa pine over limited areas are so severely attacked that they are worthless for lumber.

The aggregate loss from diseases in immature stands destined for timber production is high and probably approaches or exceeds the losses caused by decay in mature stands. In the future, as mature stands are even more depleted, the damage caused by these diseases in immature stands will increase greatly in relative importance.

Native diseases of immature stands must be largely controlled by measures applied when the timber is cut. It is axiomatic that direct eradication of these diseases by a special control operation is rarely warranted, since they do not threaten the perpetuation of any commercial species. When timber is finally cut all diseased trees should be removed, leaving only healthy individuals for seed trees or for the nucleus of the next cut. This will reduce the amount of disease in the reproduction, and where early thinnings are practicable, diseased trees can be removed while they are still small, leaving the final crop composed of healthy individuals. In certain managed hardwood stands in southern Connecticut, where there is an active demand for fuel wood, it is now the practice to thin out the undesirable trees early in the life of the stand, with particular emphasis placed on the removal of oaks suffering from Strumella canker.

DISEASES AFFECTING MERCHANTABLE FORESTS

Native killing diseases affecting merchantable forests do not usually cause spectacular damage, but in the aggregate these losses are of consequence, since almost every tree killed results in a corresponding reduction in volume of the stand. Furthermore, killed trees usually occur as scattered individuals or groups so that it is economically impossible to salvage them. Parasitic fungi and mistletoes take a steady annual toll from mature stands, and occasionally unfavorable weather conditions cause heavy losses. Following a drouth period culminating in 1925, mature trees died so extensively in the bottomland hardwood region of parts of the South, that the loss was believed to equal a normal year's cut by the mills of the region. Occasionally groups of mature trees are killed by lightning. While little can be done to prevent killing of mature trees by adverse climatic conditions, it will ultimately be possible to reduce losses caused by fungi and dwarf mistletoes, through the elimination of infected trees when the stand is cut so that the new, immature stand will not be exposed to infection from old, diseased individuals.

The great loss from fungus action in merchantable stands is in the destruction of heartwood of living trees by decay fungi. In Douglas fir, the timber species on which the most extensive data are available, this loss amounts to 17 percent. Since Douglas fir comprises nearly one third of the remaining saw timber of the entire United States, the cull in this species alone means that more than 5 percent of our apparent timber supply is worthless. In other species of which the remaining stand is much less, the percentage loss through decay is even higher. In the mixed coniferous forests of northern Idaho, western hemlock is so badly decayed as to be largely unmerchantable. Throughout much of the range of white fir, cull from decay is so heavy as to amount to complete destruction of the merchantable stand. In the Adirondack Region of New York, loss from decay in beech is so high as to make this species of doubtful value. The same species is so defective in the bottomland hardwoods of Louisiana that it is frequent practice in logging operations to leave all of the beech trees standing. It is figured in the northern Rocky Mountain region that defect, largely decay, increases the unit cost of timber production in nearly the same ratio as the occurrence of the defect itself. In addition a much larger ratio of low-grade lumber is produced from a defective stand than from a sound one of similar growth rate. These lower grades are difficult to sell even during a high market, and nearly impossible to dispose of when lumber prices are low. Decay in the forest may thus result in over cutting in order to meet the demand for high-grade stock; in too high cost of high-grade stock; in the glutting of the market with low-grade stock; in financial injury to both the producer and consumer interests.

A summary of the loss from decay in saw timber in the United States is given in table 1. The figures on decay percentage, although based primarily on estimates made in 1923 by lumbermen and by State and Federal foresters for eastern species, with the same basis supplemented by actual measurements for certain western species, have proved reasonably reliable, for most of the species on which it has been possible to check the original estimates by measurements obtained since that time. For example, the original estimates placed the loss in Douglas fir at 15–20 percent and the lower figure was adopted to be conservative. Later, exact measurements on a large number of plots of felled timber of various ages placed the average loss in board foot volume at 17 percent. For a number of other species similar checks have been obtained, but based on fewer data. The figures in the present table are lower than the 1923 estimates by 1 percent each for oak and southern pine, 2 percent for gum, white and Norway pine, and lodgepole pine, 3 percent for cottonwood and aspen, 8 percent for western hemlock, and 17 percent for redwood. The percentage for cypress has been raised by 4, and for western red cedar by 5. The general trend is toward less cull, because a decreasing proportion of our merchantable timber is in old-growth stands.

TABLE 1.—*Estimated cull due to decay in the standing saw timber of the United States*

Species	Estimated cull	Species	Estimated cull
Eastern hardwoods:	*Percent*	Eastern softwoods—Continued	*Percent*
Oak	19	White and Norway pine	8
Birch, beech, and maple	21	Others	11
Red gum	13	Western softwoods:	
Chestnut	17	Douglas fir	17
Hickory	13	Ponderosa pine and Jeffrey pine	6
Cottonwood and aspen	19	Western hemlock	20
Ash	8	True firs	18
Yellow poplar	14	Redwood	13
Others	18	Western white pine and sugar pine	7
Eastern softwoods:		Western red cedar	20
Southern yellow pine	5	Lodgepole pine	8
Hemlock	18	Spruce	15
Spruce and fir	9	Others	20
Cypress	17		

This table does not include the loss in cordwood stands nor in timber too small to be merchantable in which decay has already commenced. Hardwoods, largely concentrated in the East, have a higher loss than softwoods, while in the softwoods the eastern species are considerably less decayed than the western. This is because the eastern softwoods are largely cut over, and the saw timber is much younger on the average than that in the West.

Young timber is relatively free from decay, but as the age of a stand increases, loss from decay increases steadily. This loss is offset somewhat by volume growth of the trees which is rapid in youth but slows down at about the same time as decay is accelerating. Finally, a point is reached in highly defective stands at which volume of decayed wood increases more rapidly than volume of sound wood, and the stand suffers an increasing net loss year by year. This condition is shown in figure 1 for white fir in California where between the ages of 280 and 300 years, loss from decay offsets the amount of new wood added to the tree. For Douglas fir in western Oregon and Washington on good sites, loss from decay at 100 years on the average is 1 percent, at 200 years 8 percent, at 300 years 18 percent and at 400 years 36 percent; at 300 years the volume increase in decay equals the volume increase in sound wood, and from that age on stands suffer an increasing net loss. These two examples serve to illustrate the general principle, but so far investigations have made this information available wholly or in part for only a few species, notably western white pine in northern Idaho, quaking aspen in Utah and Minnesota, and incense cedar in California, in addition to white fir and Douglas fir previously discussed.

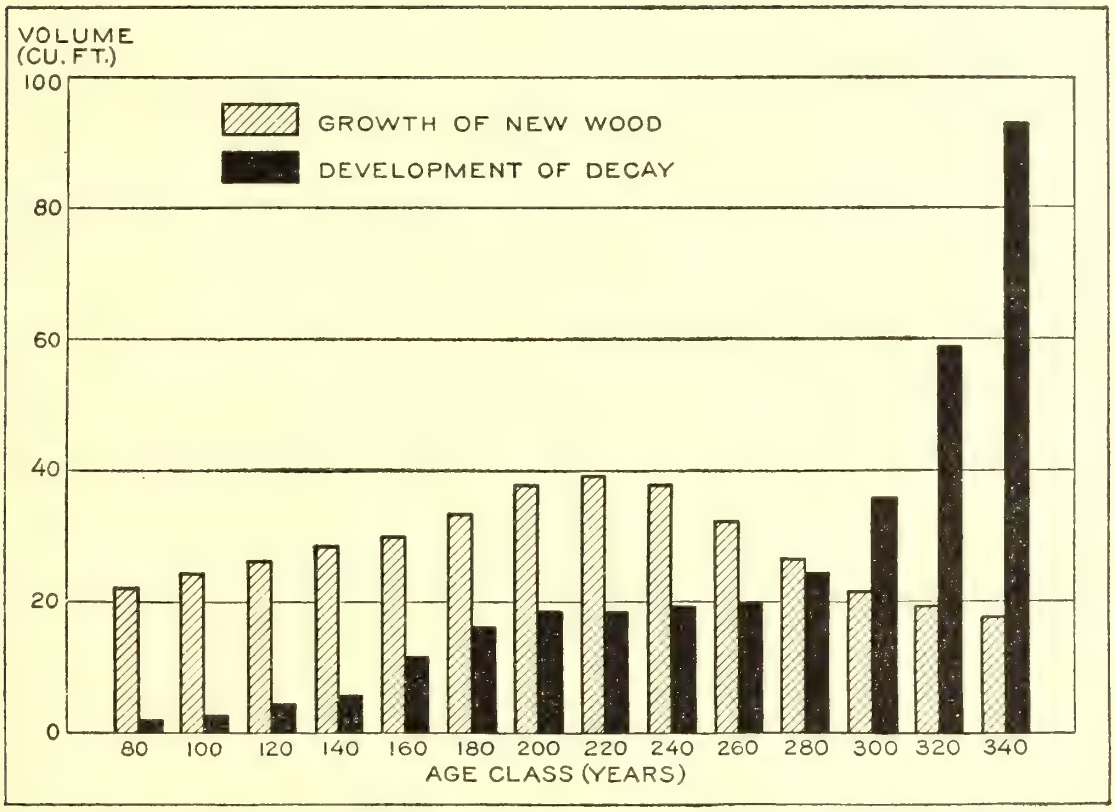

FIGURE 1.—Rate of increment of decay in white fir (California). Through youth and middle age the growth of new wood is much more rapid than the development of decay. Above the age of 280 years the increase in decayed wood exceeds the total increase in tree volume for the same period.

The fact that decay increases with age of stands makes the method for prevention of serious losses obvious; that is, determine the age for each species at which decay becomes of economic importance, and cut the trees before this age is reached. In addition, in order to intelligently handle the overmature, highly defective stands now existing with the minimum loss, it is necessary to know the rate of decay at different ages for the component species, so that those stands in which the most rapid loss is occurring can be first harvested where possible. Then, too, it is necessary to understand the outward indications of decay in standing timber, so that timber estimating may be placed on a more exact basis, since logging operations are based on the amount of timber that can be obtained from a given unit of area as determined by estimate. If decay is underestimated in a highly defective stand, the amount of timber obtained may be so much less than expected that it is not possible to make a profit on the operation, since more milling and logging equipment would be set up than the volume of timber warrants. Again a knowledge of the outward indications of decay makes possible more intelligent utilization of standing timber. For example, in the Douglas fir region, it is now possible to judge the amount of decay in individual trees with considerable accuracy, so that felling and bucking charges on them are avoided.

In forecasting losses from decay in timber stands of the future it is reasonable to presume that utilization will not only be at earlier ages than at present but that it will be closer. At current levels of value and with lumber as the chief product a considerable amount of sound wood adjacent to decay has to be sacrificed because its salvage cannot be made to pay. There is reason to believe that in the future not only will wood values increase to some extent but that a larger proportion of the cut may go into cellulose, alcohol, or other derived products in which closer utilization is possible. The loss in cull due to decay may therefore be expected to be lower.

In many species, decay commonly enters the tree through open wounds, and the most common wounds are fire scars. Decay then first destroys the wood in the basal part of the trunk, which is commonly the most valuable portion of the tree. In small trees the only saw timber of satisfactory grade is often in the first 16-foot log. In eastern hardwoods most decay, which frequently begins at an early age, is directly connected with fire scars. Consequently in most forest regions adequate fire protection is a valuable method of reducing losses from decay.

From the foregoing, it might be concluded that by sanitation in connection with thinning and logging operations, by utilizing the trees at younger ages and by improved methods, and by better control of fire, the disease losses in the forests of the future should be less than in the virgin stands which have been our principal source of forest products in the past. For two reasons it is impossible to take this expectation at its face value. In the first place, the desirable practices just mentioned are not being applied to most of our stands. Only a small part of our forest area is really under management, and under present economic conditions most of it cannot profitably be put under any but the most superficial management. Much of our second growth has been more fire scarred than was the virgin forest, and in addition has been subjected to undue mechanical wounding during the logging process. Instead of aiding in sanitation of forests, the bulk of our logging operations have removed the best timber and left the worst infected trees in the woods. In the second place, though we call them natural forests the stands that are coming back on old fields and cut-over land are developing under conditions that are in many ways abnormal. While their health prospects are better than for plantations, the soil conditions, stand density, and species mixture may be quite different in young natural forests from those developed under truly natural conditions. Whatever the reason, there appears in some cases to be more disease damage in second growth than is found in trees of the same age in virgin forest. It is probable that future timber crops as a whole will suffer less cull because of heart rots than did the original stands. For other types of disease it would be altogether unsafe to predict any diminution in damage and it is entirely possible that our new forests will be considerably less healthy in some respects than the old ones.

RELATION OF FOREST DISEASES TO RECREATIONAL USE AND WATERSHED PROTECTION

The foregoing discussion of diseases has been limited to forests as sources of wood. Two other uses of forest land of increasing importance are for recreation and for watershed protection. The pathological problems connected with these uses differ in a number of respects from the problems connected with the growing of timber. High elevation forests and forested areas near cities, often low in timber-producing capacity and growing under quite different conditions from those in the best timber stands, are among the most valuable for these other purposes. There is an increasing number of forest areas that are set aside for municipal water supply, or as national, State or local parks entirely for recreation, in which the standards for judging diseases and the practices that influence them are very different from those previously considered.

The effect of native diseases on watershed protection is apparently slight. So far as our present knowledge goes, native diseases do not materially lower the efficiency of forest cover either in delaying run-off of water or in preventing erosion. It is altogether probable that in some places, particularly in the drier parts of the country, diseases do reduce the production of litter sufficiently to lessen the water-absorbing capacity of the forest floor; or that they operate to keep the finer roots from occupying and holding the surface soil to the normal extent. Such effects are not conspicuous and careful experiments continued through a period of years, too expensive to be justified under present conditions, would be needed to determine their importance.

The relation of forest pathology to recreational use is not so simple. It is true that there is no obvious way in which ordinary diseases impair the value of the forest for game purposes. In areas used primarily for recreation, tree diseases, generally speaking, are of importance only when they detract from the beauty of the landscape or upset the natural balance of plant associations which should be maintained so far as possible. Heart rots and growth-reducing diseases that might make the difference between profit and loss in a timber-growing project have much less effect on aesthetic values; in fact to some people, hollow trunks and gnarly or irregular crowns make trees more picturesque. However, killing diseases often materially hurt the appearance of the forest. Trunk and butt rots predispose to windbreak and windthrow and such trees are dangerous in the immediate vicinity of roads, trails, and camps. Diseases which cause a conspicuous amount of unsightly yellow and brown dying foliage are sometimes very objectionable.

Incongruous though it may seem, the genus Homo, for whose pleasure these tracts have been set aside, continues to be the chief menace to their beauty and permanence, and many areas, especially in the vicinity of hotels, camp and picnic grounds, have already been damaged to such an extent as to impair their value for decades, if not for all time. Continual trampling of feet and frequent building of camp fires completely remove the surface humus which provides organic matter for the underlying soil and causes pronounced compacting, thus creating such unfavorable conditions for plant growth that many fine big trees, often several centuries old, are killed directly or by root fungi or other parasites that take advantage of these adverse conditions. Constant and indiscriminate use of automobiles in such areas leads to mechanical wounding of many trees and to soil poisoning by dripping of oil and gasoline. More must be known particularly as to the way in which campers and tourists affect diseases by changing soil conditions. The loss of two or three dominating trees on a camp ground may cause more real reduction in value than the killing of as many acres of remote timberland. Intelligent location and planning of sites for this intensive use and more adequate supervision of their occupancy will be essential to prevent damage.

DETERIORATION OF KILLED TIMBER

Occasionally there are extensive stands of mature timber that have been killed by such agents as fire, insects, windthrow, and more rarely introduced parasitic fungi. Killed timber rapidly deteriorates from checking, staining, wood-boring insects, and decay, the rate of deterioration varying with the tree species involved. Prompt removal and utilization of such timber is the only effective method of salvage. This is not always possible either because of economic conditions or because the aggregate volume killed while large is so scattered that it cannot possibly be salvaged at a profit. Where bark beetles have done the killing, stain fungi that entered with the beetles are already established in parts of the sapwood by the time the trees died.

In 1921 more than 3.5 billion board feet of very large merchantable timber of high quality was windthrown on the Olympic Peninsula in Washington. At the end of the first season of exposure the loss in Douglas fir amounted to 1 percent, in Sitka spruce to 3 percent, and in western hemlock to 13 percent. By the end of the sixth season the losses were 19, 36, and 78 percent, respectively. From the fourth season on, most of the loss was caused by decay, and during the first three seasons by blue-staining fungi and wood-boring insects.

Balsam fir killed by the spruce bud worm in northern Minnesota and Wisconsin is so quickly decayed that stands are not worth salvaging after the third year of exposure.

Chestnut presents the most important problem in timber salvage which has ever faced the United States. The chestnut blight is responsible for the death of millions of acres of chestnut timber from Maine to Alabama. In New England and the Middle Atlantic States where the disease first struck, fair prices simplified the marketing problem. In the southern Appalachians, where the menace was not appreciated by timber owners until after the World War, a glutted lumber market accompanied by ridiculously low prices has made utilization difficult.

Fortunately chestnut heartwood is unusually durable; investigations have shown that the tannin content is not materially less in trees dead 20 to 30 years than in living trees. For the first 10 years after a tree is killed by the blight, the loss in wood volume from decay is not important. After that time, windthrow increases markedly and the down trees deteriorate at a much more rapid rate than those left standing.

While in time the extract industry can very likely utilize a considerable part of the killed southern chestnut, every effort should be made to promote its immediate use for other purposes for which it is suited.

Reports from some New England pole-using companies indicate that the average service life of untreated chestnut poles set in recent years from local cuttings is materially shorter than that formerly secured. Whether this is due to the use of blight-killed poles which have been standing dead in the woods for some years before use, the increased prevalence of chestnut heartwood decaying fungi or some other factor is unknown.

DETERIORATION OF FOREST PRODUCTS

Fungi, microscopic plants which include in their number the principal causes of disease in forest trees, are also the most important causes of deterioration of forest products.[2] The fungi attacking forest products belong to two distinct groups. The stain and mold organisms consume the contents of the wood cells with relatively little damage to their structure or strength, the losses they cause being due to the discolorations that result. The decay fungi by attacking the cell-wall material weaken and ultimately soften the wood, or may even completely destroy it. Both groups are able to grow only in wood that is moist but not water-logged. The less important discoloring fungi will be considered first.

STAIN AND MOLD

The fungi that cause both of these defects are practically limited to the sapwood. The slender filaments of the stain fungi that penetrate the wood give it a permanently darker color, commonly bluish in cast, and therefore often referred to as blue stain. The mold fungi are related organisms that happen to have colorless filaments so that only their surface growth is visible, and all signs of their presence disappear if the wood is planed. Therefore, while molds interfere with sales of certain kinds of material, they are less important than stain. Stain decreases the marketability of wood for most purposes and in pine it throws lumber down into the lower grades which bring a price less than the cost of production. Sap stain thus aggravates the glut in the market for the very lowest grades of lumber. It affects the drain on timber resources by increasing the tendency to overcut the forest in meeting the demand for the higher grades of lumber. This in turn results in a still further oversupply of the lower grades, and a still greater difference in prices between upper and lower grades. Pine and gum are most susceptible to damage, and wood from second-growth stands is more affected because of the higher proportion of sapwood. For both of these reasons the sap-stain damage is greater in the East than in the West. In pulpwood it is also something of a factor, making necessary stronger bleaching treatment in paper manufacture. The overcut to replace high-grade material that has been reduced in grade by the staining fungi has never been estimated on a quantitative basis;

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[2] Insects as agents in the deterioration of forest products are considered in the section entitled, "Progress of Forest Entomology."

it is much less than the overcut due to decay, but since it is in material that can be derived only from saw timber, it is a considerable element in forest depletion.

Most loss from sap stain occurs in saw logs that are delayed in getting to the mill, and in lumber during the first few days after seasoning. Log stain has proven very difficult to avoid when conditions prevent prompt milling. Surface spraying treatments have proven experimentally successful for protection during the ordinary log-banking season in the South, and are about to be tried on a large scale. For lumber that has not been stained in the log, kiln-drying is an excellent preventive, but is in use only in the higher grades and at the larger mills. A promising recent development obtained by the Department with the cooperation and financial assistance of southern lumbermen is the discovery of inexpensive antiseptic dips more efficient than any previously known, effective on hardwoods as well as on pine, and practicable for use by small as well as large mills. These are already in extensive use, but further experiments are needed to firmly establish the procedure. With perfection of the details of the treatment, and adequate educational work among the small operators, both on the antiseptic treatment and the general handling practices that decrease stain hazard, it is believed that the financial loss and excessive drain due to sap stain will be very materially decreased. Foreign customers are particularly insistent on wood that is free from stain, and exports of southern lumber have already been favorably affected as a result of the improved appearance of the treated wood.

LOSS FROM DECAY

The principal loss in wood volume due to decay of forest products is in logs banked in the woods or at the sawmill, lumber and sawn timbers in seasoning or storage piles or in exposed construction, fuel wood and pulpwood in storage, and ties, fence posts, and mine timbers in storage and use. The proportion of lumber and fuel wood lost by decay is not high, but because of the very large volume of these items, they supply an important part of the total decay loss. The losses in ties, posts, and mine timber are large because of the moist conditions under which they are used. Poles and piling are also used under conditions that favor decay, but because of the relatively small volume of use for these purposes their effect on the total loss is much less. Decay losses necessitate the cutting of additional timber for replacement purposes. It is estimated that the overcut necessary to replace decay losses in all classes of forest products amounts to more than 10 percent of the total cut. For products derived from saw timber, the estimated overcut required for decay replacements is approximately 9 percent of the saw timber cut, which is a smaller figure but more significant not only because of the greater value of saw timber but because of the slow rate at which losses of saw timber are replaced by growth. On the basis of 1925–29 production, the decay replacement estimate for saw timber is found to equal half of the estimated current growth for this class of material.

The consequences of decay to both producer and consumer of wood and wood products are out of proportion to the value of the material destroyed. Production costs are increased by storage and transit losses. The higher costs hamper the lumberman in competition with producers of wood substitutes and impose a hardship on the consumer. The replacement of wood that is damaged by fungi after it is put in service entails labor and other incidental costs that total much more than the price of the wood used for the replacement. Costs of replacement material cannot be exactly determined, because the losses occur at different stages between felling in the woods and use in buildings, fence lines, etc. Making rough allowances for this fact, as well as for the labor costs of making replacements, it appears that on the basis of the production and prices of the years 1925–29 annual costs of replacements because of decay averaged more than a quarter of a billion dollars, and were thus more than half as great as the annual fire losses reported by the Board of Underwriters for the same period. Furthermore, particularly in the case of house construction, the uncertainty element due to sporadic and spectacular cases of destruction by dry rot causes builders to turn to the use of wood substitutes to an extent greater than the average damage would warrant, with unnecessary losses in economy and often in utility. Decay in forest products, therefore, causes immediate loss to industry and to the public, as well as ultimate loss to the country from the resultant overcutting of the forest and depletion of an important natural resource.

In comparing the losses due to fungous deterioration of forest products with the losses due to diseases of the living forest, it is probable that the products losses are less serious as a cause of depletion of timber resources. When, however, the immediate financial effect is considered, it appears that the damage to forest products exceeds forest diseases in importance. This is due to two factors: The wood in the form of forest products is worth several times as much as the stumpage of the timber from which it came; and the heavy costs in other items incidental to replacements further raise the total damage figure.

PREVENTION OF DECAY

A large wood-preservation industry has arisen within the last 40 years, and particularly by its accomplishments in tie preservation it has made a notable contribution to the conservation of timber resources. There is still need for improvement in methods of preservation and for its extension to a larger proportion of the material used. Too little progress has been made in the preservation of wood that is to be painted or stained, or used in dwellings. In most parts of the country it is difficult or even impossible for the small consumer to get treated lumber. Current treating methods are expensive, and some of them are suspected of making the treated wood dangerous to the users. Particularly in the South and on the Pacific coast, the destructive dry-rot fungi establish themselves in new buildings and cause extensive damage which, in some cases, proves very difficult to stop unless treated wood is available for critical parts of the structure.

There is also room for material improvement in other practices as well as in wood preservation. Prompt utilization or the seasoning of green material, subsequent protection from the moisture that decay fungi must have in order to attack the wood, and sanitation in lumber yards are practices which help to prevent decay, but they are often ignored and in many cases it is impracticable to follow them. Research needs to be extended both in the direction of field trials for the simplification of protection methods based on principles already discovered in the laboratory and in the direction of further fundamental research without which entirely satisfactory field methods can never be developed. Both the present information and that later developed need to be made more readily available to the smaller wood producers and wood users by service and demonstration work.

OUTLOOK

Among the factors tending to increase damage by fungi to forest products are the increasing volume of small-mill lumbering, use of less durable species and of a higher proportion of sapwood, and the architectural trend toward low foundations. However, practicable improvements in seasoning and preservative processes and in building practices, and the increased use of treated wood or of wood substitutes in situations of high-decay hazard, should more than counteract the unfavorable factors and result in some net decrease in decay damage, as well as in decided decrease in the losses from sap stain. The possibilities in the way of preventing fungous damage are much greater in forest products than in forest trees. The products losses have already been reduced far below those that would occur without active control procedure. It would be technically possible to develop practices that would prevent practically all loss; it is doubtful, however, if the reduction in fungous damage in the next 20 years will be any more rapid than the reduction that is expected in forest growth. Increased protection against fungous attack will take place concurrently with advance in three processes: Research aimed at the cheapening and simplification of protective methods, education of wood users as to improved practice, and increase in lumber prices which will increase the number of types of use in which protection is cheaper than replacement.

Further consideration of the pathology and protection of forest products will be found in the section entitled "Enlarging the Consumption of Forest Products."

FOREST DETERIORATION BY INTRODUCED DISEASES

In the foregoing nothing has been said of the dangers of serious and widespread epidemics. Native fungi, or fungi that have been introduced in the remote past and to which our forests have already become adjusted are not likely to cause catastrophic epidemics in native tree species or threaten the extermination of any commercial forest tree. The introduced disease, on the other hand, is a potential danger to the commercial existence of every one of our commercially important timber species.

The history of agriculture and horticulture in this country prior to the passage of the Plant Quarantine Act of 1912 and to the issue of the general nursery stock importation restrictions in 1919 was a procession of invasions by both plant diseases and insect pests from abroad. Wheat, potato, cotton, corn, asparagus, and peach are among the important crop plants that have suffered from foreign attack at one time or another in our history. Most of the attacks have been met by the quick substitution of resistant varieties, by a shift of the center of cultivation from one part of the country to another, by changes in methods of cultivation, or by expensive methods of direct control, such as spraying the plants. None of these procedures are possible in forests. The ultimate result in agriculture has been more complicated methods of production and increased cost to the consumer. In forests similar invasions of virulent pests are likely to mean the loss of valuable tree species and permanent reduction in forest values.

As the result of the unfortunate experiences which we have already had, the impression has developed in certain quarters that any foreign fungus will do more damage than a native fungus of the same type. This impression is incorrect. Most foreign fungi when transferred to a new habitat find that the climate or the lack of the food materials to which they are accustomed makes it difficult for them to exist in competition with the better adapted native organisms. However, a foreign fungus which does find among our tree species one which is a congenial host may do to it exactly what the blight has done to our chestnut, or at least may injure it more than any native fungus could possibly do, because to the foreign fungus the tree lacks the specific resistance which in past ages it has acquired to the native parasites.

A foreign fungus may attack in a less conspicuous manner than the chestnut blight and develop more slowly but nevertheless to a sufficient degree to ultimately take most of the profit from the management of the host species. It often happens that the introduced disease is not at first recognized as such. A number of the diseases that are now causing concern in the United States are under the suspicion of having been introduced, but if they have been introduced it was so long ago that their history cannot be determined with certainty. Among those that are known or suspected to have been originally introduced are enough different types to illustrate most of the kinds of damage that we have to fear from diseases from other countries.

The one that first occurs to the minds of everyone familiar with eastern forests is chestnut blight, an importation from Asia. In a period of approximately 40 years since its probable time of entrance is has destroyed one of our half dozen most important hardwood species through the northern two thirds of its range. There is still available a large volume of chestnut saw timber in the southern Appalachians and more widespread utilization of this chestnut lumber would assist in conserving our limited stands of other eastern hardwoods. But this southern Appalachian chestnut region is now infected with the blight, which is rapidly advancing and will in time eliminate the American chestnut as a commercial tree. Chestnut, because of its excellent growth even on the poorer soils, its ease of management, the value of its nuts, the high durability of its wood, and consequent usefulness for a number of purposes, was perhaps the most valuable single species of all our hardwoods. It still furnishes over half of our domestic tanning materials, and has the unique feature that the tannic acid is taken from wood which is not wasted but can then be converted into paper. No satisfactory domestic substitute for chestnut tannin has been found. Fortunately chestnut can be used for tannin production for 20 or more years after the trees are dead. Other species have promptly replaced the chestnut on the better sites; we therefore have not extended our idle land or had any serious watershed problems as a result of this unprecedented epidemic, but much of the land on which the chestnut formerly predominated is permanently reduced in commercial value as a result of the change to less profitable species. This loss of productiveness of the former chestnut land is an even more serious matter than the immediate loss of the merchantable chestnut stands.

Where the disease has run its course and killed practically all the trees, the causal fungus has decreased in abundance locally for lack of food material, in some places to an extent sufficient to permit the new sprouts to attain a considerable size and even to bear nuts before becoming infected. In the cases that have been kept under observation for a sufficient length of time the evidence is that these new trees are susceptible. Despite much search by both governmental and private agencies, no native trees that have been tested so far have shown enough resistance to enable them to produce merchantable stands in the presence of the disease. During the past 20 years large numbers of promising trees and sprouts which continued for a while to develop in the presence of the blight have finally succumbed. Trees and sprouts in 200 different localities in 18 States are still under observation by the owners in cooperation with the Department to determine if they really are resistant. While it is to be hoped that some individual native trees may yet be found so nearly immune that they can be used as propagating stock for the replanting of the American chestnut, the statements recently given prominence in the public press that the chestnut is coming back, are, to say the least, premature. Strenuous efforts are being made to find Asiatic chestnuts that will be resistant both to blight and to American parasites, or to produce hybrids with the American chestnut that will serve the same purpose. These efforts may ultimately give us as good a tree as the one we have lost; but any such result must require many years of work, and if actual reestablishment of all the chestnut forests prove practicable, it will require generations to accomplish it.

The white pine blister rust, perhaps as well known as the chestnut blight, stands in quite a different category from the chestnut disease. It was introduced to this country from Europe, though it may have come originally to that continent from Asia. In the eastern United States it works more slowly than the chestnut blight, but is nevertheless an unusually conspicuous disease and was recognized at a relatively early stage in its American development. One weak point in its life history, namely, its need for a currant or gooseberry bush as an alternate host, has made it possible to evolve a method of protecting our most valuable northern white pine stands before it had time to cause great injury. Reproduction has been considerably reduced in some places in the Northeast and in the Lake States, but the control campaign has in general safeguarded us against heavy losses in merchantable stands and promises to make it possible to continue the growth of white pine in most of its original commercial range. The only places in the main commercial range where the northern white pine may be forced out as a commercial species are some in which the cost of eradication of the currants and gooseberries is excessively high or where attack by other diseases and insects makes the species too difficult to maintain when the added costs of blister-rust control are considered. A dying out of the species is to be expected in the marginal portions of the range, where its representation in the stand is not heavy enough to justify control measures. On the other hand, in some of the outlying sections where the alternate hosts can be cheaply eradicated and growth rate and markets are favorable to the pine, it is probable that white pine production in the future will be greatly increased through planting. In the major portions of the range in which protection is practicable, the cost per acre of the protection ranges from 5 cents to $2 per acre, with an average of 44 cents. This figure covers all charges—Government, State, and local, as well as the actual cost of removing the bushes. In most places eradication of alternate hosts is advisable at about 5-year intervals, but the cost of these later eradications is less than that of the initial one.

The status of the blister rust in the West is less hopeful. Western white pine and sugar pine are still more susceptible than the northern white pine, and the currants and gooseberries that act as alternate hosts in the West are more numerous, more congenial to the rust, and more difficult to eradicate. Both the infection and the control campaign in the West are relatively recent, and the proportion of the stand of these two important western timber species which can be protected from rust at a practicable cost in the present profitless state of the local lumber industry remains to be determined. It is feared that most of the privately owned white pine stands of Idaho will be destroyed because of the inability of the owners to finance control.

Both the chestnut blight and the blister rust, where allowed to run unchecked, affect the æsthetic and thus the recreational value of the forest to an extent not encountered with most native diseases. So many trees are killed at once that it takes many years to replace the skeletons of the killed trees with enough trees of other species to restore the beauty of the forest. To a great many people the species which replace them are decidedly inferior in beauty to the chestnut with its remarkable spreading branches or to the white pine with its dark masses of foliage.

In the case of chestnut blight, the wholesale killing of the trees on thin soils on upper slopes in places in Pennsylvania has in some cases resulted in soil deterioration through opening up of the stand to such an extent that the humus layer has disappeared and centuries may be required to restore the original value of the watershed.

Even where a lost timber species is replaced promptly and completely by others of equal commercial and aesthetic value, there is chance for indirect and deferred damage to the forest. Most of our forests are balanced associations of a number of species of trees and shrubs, and the soil organic matter is largely controlled by the species mixture. There are numerous ways in which these species can affect each other, and the complete removal of any of the commoner species may result in soil changes unfavorable for the entire association, or in otherwise so unbalancing the forest-tree community as to seriously reduce its productiveness.

The other introduced diseases of our time appear thus far to be less serious because they are less active, because they are attacking trees of less economic importance, or because they have been introduced in localities where the most susceptible native tree species are not common. One which appears particularly virulent is the willow blight, caused by a leaf and a twig fungus working in partnership, both of them introduced. This disease in the willows of the Northeast has made a record for quick killing. It is destructive in this region on several native willow species. If in its spread over the country it is found to be equally virulent in regions farther south and west, or if forestry developes further in the direction of cellulose production so that willow can become important for wood production in bottom lands, this disease may yet prove very serious. The willow is the one tree best adapted to the holding of the soil on the banks of streams in some parts of the country, particularly in the Middle West. It is impossible to predict to what extent flood-control problems might be aggravated by the loss of the willows. There is no prospect of direct control for this willow disease, but there is an unusual chance for the substitution of resistant willow species or of resistant varieties of susceptible species for the willows that are destroyed. The short generations and easy vegetative propagation of the willow greatly facilitate breeding of resistant varieties.

The larch canker illustrates a very different type of a recent importation. This larch disease has long been troublesome in European forests. It was brought to this country on imported stock from Scotland a score of years ago. Because of the small amount of larch in the locality where it was introduced, it spread slowly, and since its discovery the entire eradication of the known cases has apparently been successful. So far as known it no longer exists in this country, but some years of follow-up work and more extensive reconnaissance are necessary before it will be safe to say that the fungus has not succeeded in establishing itself anywhere in our native larch. Had the disease been introduced originally into a region containing much larch, the story of this introduced disease would have less chance of having a happy ending.

The so-called Dutch elm disease which was apparently introduced into Europe has done tremendous damage in the elms of the low countries and has now extended into the British Isles and through Middle Europe. It has been found recently in Ohio; but in spite of the most energetic search, in which the cooperation of the public and the commercial tree surgeons has been enlisted, it has been discovered to date on but eight trees. Wherever found it has been eradicated. While the American elm is known to be highly susceptible, we have reason to hope that the disease is not yet present elsewhere in the country or that conditions in this country, as for example the absence of one of the insects which appears to aid in its spread, will prevent its active operation in our elm species. The loss of the elm would, of course, reduce our timber resources in certain locations and for certain purposes, and make a tremendous inroad on our tree resources from the æsthetic standpoint in the North and East; in New England it is more important as a street tree than all other species together.

One of the most recent attacks of a possibly introduced disease is affecting the two most important pines of the northeastern States. Both northern white and Norway pine are being killed by a resinosis at the base of the trunk in three New York plantations. If not distributed on nursery stock, this disease will probably be unable to spread rapidly. However, in forests it is obvious that a slow but sure spread can ultimately be quite as serious as a more rapid spread.

This new disease has been under study by the New York authorities for three seasons, but because of the complications entering into root-disease investigation it may be several more seasons before we can be certain of its antecedents or just what may be expected of it in the country as a whole. This illustrates one of the weaknesses in our preparedness against introduced diseases. We are yet so little acquainted with the native diseases of our 180 commercial timber species that when a previously unobserved diseased condition is found it is often difficult to decide whether it is native or introduced.

The newest threat is to the beech. A bark fungus of unknown source has joined with a scale insect to destroy 40 percent of the beech of Nova Scotia. Infection has now appeared in Maine, where it is still very limited but is spreading with alarming speed.

Serious as some of the foregoing cases are, there is some reason to think that we have scarcely begun to suffer from introduced diseases. To lose a single species from among our numerous forest trees is not a complete disaster but to lose several from the same region might very seriously cripple forestry both from the timber production and the recreational standpoint. It is very probable that we already have a large proportion of the dangerous fungi that were native to Europe. Up to 1912 the United States Government had no legal authority to exclude diseased propagating stock, and it was only after the quarantine regulations of 1919 that the policy of free trade in plant diseases really came to an end. However, considering the great number of forest species related to ours which are found in Asia, and the relatively small amount of commerce which we have had with Asia, Africa, and South America until recent years, it is probable that we have thus far been exposed to relatively few of the potential tree-disease organisms of those continents.

Diseases brought in before 1919 may yet remain to be discovered. A single importation of a disease, even if it be a virulent one, seldom spreads far enough to be discovered or brought to the attention of our small staff of forest pathologists until it has been in the country at least 10 or 15 years. While the quarantine regulations now in force have undoubtedly prevented or greatly delayed the introduction of pests since 1919, no system of quarantine which it is possible to enforce at present can guarantee absolute exclusion of new diseases indefinitely. Yet every delay in introduction is vastly important, not only because it avoids damage or costly readjustment to the intruder but also because we are likely to be able to meet the newcomer in the future with a more organized and efficient effort than can now be directed against it. Complete enforcement is impossible, and quarantines cannot be applied to some kinds of imports without excessive interference with commerce. For example, it appears impracticable to limit the importation of wood in the form of logs, pulpwood, or packing cases, though there is considerable possibility that these imports may bring with them tree diseases of the vascular-wilt type exemplified by the maple wilt and the so-called Dutch elm disease, as well as fungi that will add to our deterioration problems in forest products. Few introduced organisms would be as easy to control as the blister rust. From the nature of the case, any prediction is highly speculative, but the probabilities favor trouble from now unknown foreign diseases for others of our important tree species.

The introduction of dangerous organisms is not limited to the bringing in of new species. It is now well known that our most important fungous species consist of numerous strains, some of which differ from others very clearly in their virulence. For example, the well known root-rot fungus *Fomes annosus* is common throughout both Europe and North America. In the Douglas fir in the Pacific Northwest it is very frequently found, but appears to be unimportant so far as parasitic activity is concerned. In Europe, on the other hand, it is an extremely serious parasite in planted forests and causes heavy damage to European plantations of our own Douglas fir. There is reason to believe that some of the European strains of this root-rot fungus are more dangerous than any of those which we now have; their importation might prove serious, particularly for our reforestation projects.

Introduced diseases must be found, studied, and if possible eradicated while they are new in this country. Delay may mean their escape beyond control. To permit infectious material to remain undisturbed for study in our forests or among shade trees is manifestly unsafe. The knowledge of the disease, its methods of spread, and the vulnerable points in the life history of the causal organism, essential for effective eradication, can be acquired safely only by studies abroad in the countries where the disease is already established and these studies need to be carried on at the earliest possible moment after the discovery of a disease in America. In the cases of virulent diseases known to exist abroad and to be able to attack trees related to our forest species, but which have not yet gained entry into America, it is the part of wisdom to conduct preliminary studies in the foreign countries to get information that will enable us to prevent or at least to delay as long as possible their introduction here. The Dutch elm disease is an example of a case in which studies abroad are needed. At the present moment no one can answer the question, How did the elm fungus reach America? We cannot know just how to quarantine or where to expect additional outbreaks and combat them intelligently and effectively till this question is answered.

Troublesome diseases may be introduced from other parts of our own country as well as from abroad. While it is possible that most of the dangerous fungi native to this country are already present in every part of the continental United States in which there is any common native host that is particularly susceptible to them, this is by no means certain. A fungus living harmlessly on the outer bark of eastern hard pines has been proven able to cause severe damage to Douglas fir in the East. This tree in its natural range would probably be more resistant to the fungus; but if the fungus should reach the western forests and should there prove able to attack this most important species as it does in the East, we would have a forest calamity. An example of danger from the movement of native diseases in the opposite direction is afforded by the dwarf mistletoes of pine. Probably the most important of the growth-reducing parasites, they are now limited to the West, and are separated from the eastern pine stands by a belt of prairie hundreds of miles wide along the hundredth meridian. These mistletoes are not spread by the wind as are the fungi and can establish themselves in a new place only if both sexes are introduced. It is probable that the eastern conifers have never been exposed to them. Artificial inoculation experiments in neutral territory have shown that some of these mistletoes can attack eastern species and it is possible that if introduced to the East they would be found to be serious enemies of certain of our eastern pines. One fungus of uncertain origin which was perhaps brought from the West to the East is the so-called "Woodgate rust" occurring on Scotch pine in New York State. Injury by this disease to our valuable southern slash pine is feared if it spreads to the South.

To summarize: Introduced diseases now in this country cause less damage than is done collectively by our many native diseases, but there is reason to fear that unless quarantine is fully supported and proves highly successful, we have only seen the beginning of the introduction of acute diseases of foreign origin. Our forests may be exposed at any time to new epidemics, with consequent commercial loss of additional native timber species. While even the most serious of the native diseases limit their effect mainly to reducing the yield of forest products, the introduced epidemic disease may also cause serious loss in aesthetic and recreational value of the forest, and in some cases may diminish its value in watershed or stream-bank protection. The agencies engaged in protection against foreign diseases are handicapped by the lack of knowledge of the tree diseases in foreign countries, and their methods of dissemination which makes it difficult to establish fully efficient quarantine regulations; this same ignorance together with the insufficient knowledge of native diseases makes it difficult to recognize a new disease promptly after it gets into the country. When all things are considered, it is by no means impossible that by the end of the present century our forestry program may be more hampered by new diseases from abroad than by all of our native diseases. Movement across the country of native diseases now limited either to the East or to the West, though less dangerous than the introduction of foreign diseases, is also a basis for some concern.

PRESENT STATUS OF RESEARCH AND CONTROL

AGENCIES ACTIVE

Considering the immense area of land in this country suitable only for tree growing and the part that timber produced on this land has played and must continue to play in the economy of the Nation, the agencies engaged in developing principles for the control of forest-tree diseases are inadequate.

Federal work on forest-tree diseases is carried on in the Bureau of Plant Industry, Department of Agriculture, by the Division of Forest Pathology and the Division of Blister Rust Control. The Division of Forest Pathology is purely an investigative organization to develop principles for the control of tree diseases. In addition to the central organization in Washington, this Division maintains one or more pathologists in 3 of the 9 regional offices and 3 of the 11 Forest Experiment Stations of the Forest Service. After principles of control have been determined, their actual application on national forests is carried out by the administrative officers of the Forest Service supplemented by whatever assistance in instruction or supervision is needed from the Division of Forest Pathology to make the work effective. The same assistance is given on other Federal forest land, on State forests, and to a lesser extent on private forests when needed. As the result of a small appropriation for that purpose, the Division is now aiding the National Park Service by making a special reconnaissance study of tree diseases in the national parks and advising methods of control. The Division also maintains pathologists with the forest products laboratory for special work on diseases affecting forest products. A limited amount of study of dangerous foreign or introduced diseases has been made in the countries of origin, to secure information of value in planning quarantines and eradication work.

The Division of Blister Rust Control applies and extends measures for the control of white pine blister rust, based on principles established for it by previous research by the Division of Forest Pathology. Through cooperative agreements, the Division of Blister Rust Control maintains an organization in all States which have commercially valuable stands of white pine. This organization supervises the control of blister rust on State and private lands. The same assistance is extended to Federal land.

Aside from control of blister rust, there is relatively little work done by individual States on forest-tree diseases. New York conducts some pathological work in its conservation commission for this purpose, and the Natural History Survey of Illinois is giving attention to diseases of elm in that State. In Ohio, Idaho, Pennsylvania, Minnesota, Michigan, New York, and Connecticut and a few other States there has been investigative work carried on incidentally to teaching in the State educational institutions or to research in general plant pathology in the agricultural experiment stations. The small amount of attention to forest pathology in State institutions is probably due as much or more to the inclination and training of individual pathologists and lack of available funds than to any definite policy or lack of interest of the institutions concerned. Forest diseases cannot be investigated with the ease or speed with which results can be obtained on the diseases of smaller and shorter-lived plants; and the damage and control phases of such investigations can be adequately handled only by men who have a knowledge of forestry as well as of plant pathology. These facts have induced general plant pathologists to study forest diseases only incidentally and without the continuity of effort that is absolutely essential in the study of diseases of long-lived host plants. Many States whose forests are a primary resource do no work in forest pathology.

There are no private organizations for investigation or control of forest diseases. Three endowed universities with forest pathologists on their teaching staffs do some research. The Oxford Paper Co. in cooperation with the New York Botanical Garden is studying the diseases of poplars with a view to developing resistant varieties for the use of the company. On a few private forests there is a steady and well directed effort to reduce diseases to the minimum. In the main, the private timberland owner does not realize the presence or importance of disease unless numbers of trees are killed simultaneously. Control of white-pine blister rust has been applied over extensive areas of private forest land in the Eastern States through a cooperative service organization which has proved to be unusually effective in securing general application of the results of investigative work.

CONTROL PRACTICES

Although the basic principles of control of forest-tree diseases are fundamentally the same for all stands, the application of these principles is strongly modified by the character and location of the stand and the purpose which each stand serves. The necessity and economic feasibility for control measures vary considerably on forest lands for timber production, for recreational use, and for watershed protection. In any case intelligent control must be based on investigation of individual diseases in their relation to the stand as a whole, and the many problems demanding attention are far beyond present available resources for this purpose.

Direct control of native diseases is being practiced to a considerable extent in forest nurseries. In nurseries, trees are grown so closely crowded and under such artificial conditions that they are extremely susceptible to disease, but this same occupancy of a limited area by a large amount of valuable stock makes it possible to spend relatively large sums of money for direct-control measures, such as special methods of cultivation, soil treatment with chemicals or with steam, spraying with fungicides or iron solutions and eradication of diseased plants in the immediate vicinity of the nursery. Moderately satisfactory control methods have been developed for the more conspicuous nursery diseases, and new or obscure diseases should also prove susceptible to control when sufficiently studied.

Native diseases in the forest must be largely controlled by indirect methods, such as the removal during cutting or thinning operations of diseased trees or those in a condition to be especially susceptible to disease. The expense is mainly in hand labor, so that such operations could be carried on very cheaply at the present time. So far such efforts are largely confined to certain national forests, although a few private owners are also eliminating diseased trees in thinnings and final cuttings. A clause in national-forest timber sale contracts, first introduced in 1911, calls for cutting diseased trees even though they may be mainly or entirely unmerchantable. In California where there has been the longest experience with its operation, this sanitation cutting has been found to have a number of other advantages as well as the removal of infection sources, and if any cost must be charged to the disease-prevention feature it is very slight. It has been found that most butt rot, which is an important item in decay in conifers and the principal cause of cull in hardwood saw timber, enters mainly at fire scars, with logging scars also of some importance. This means that fire control and care in logging can be regarded as factors in disease prevention. In plantations and managed forests, disease prevalence can undoubtedly be controlled to some extent by controlling stand density. Unfortunately, information on the relation of density to disease has been determined for only a few diseases, so that wide application of this principle will have to wait for additional knowledge. The relation is sometimes indirect; for example, a high stand density can be made to help protect certain tree species from rust fungi, because it tends to kill out other species of plants that the rusts require as alternate hosts.

Investigations by the Federal Government of wood-destroying fungi that cause heavy losses by decaying the wood of trees of merchantable size, have shown for the few species studied that young stands are practically free from decay but with increasing age, losses become heavy. Consequently losses in present young stands are largely avoided if they are cut before they attain the age at which decay becomes economically serious. In addition, determination of outward indications of decay in living trees have enabled volume estimates of standing timber of certain species to be made more exactly, thus reducing one element of uncertainty in the lumber industry, since the investment in all logging operations is based on the amount of available timber determined by ocular estimates. Some operators on private land in the Douglas fir region of western Oregon and Washington have also used this information to leave unmerchantable decayed Douglas fir trees standing and thus save felling costs. There this practice will not cause increased decay in the future, because the new Douglas fir forests will be cut before reaching the age at which significant loss from decay begins. However, under usual conditions decayed trees should be cut along with the others to protect future stands. So far only a few important species have been studied and many more remain for future work.

When practicable, direct control measures must be applied to virulent, introduced killing diseases, since it is these diseases that may eliminate a native species as a factor in commercial timber production. The commercial extinction of chestnut, now in progress of accomplishment by the Asiatic blight fungus, cannot be stopped by any economically feasible measure; it had become too thoroughly established for successful eradication long before the systematic study of forest pathology was begun in the United States. The equally dangerous white-pine blister rust which reached this country some years later has been more successfully met. Investigation has shown that the fungus causing the disease must have two kinds of hosts for its existence—the pines, and currant or gooseberry bushes. While the disease can spread over 100 miles from pines to the alternate hosts, its effective spread from currants and gooseberries back to pines is only a few hundred yards; so that effective control is now obtained by eradicating currants and gooseberries in and around valuable pine stands. This control is being extensively applied on Federal, State, and private forest land in the East where about 9 million acres have been initially cleared of currants and gooseberries, and a beginning is being made in the West; but because of the greater difficulty and consequent increased cost of eradicating wild-currant and gooseberry bushes there and the rapidity with which the disease is spreading, the extent of stands of sugar pine and western white pine that it will be feasible to protect is still problematical.

Valuable protection against the introduction of diseases from foreign countries is given by quarantine. All forest trees and nursery plants are now excluded from the United States except for importation under special permit with provision for periodic inspection for the first few years after introduction. If a dangerous disease is known to exist on a foreign tree, it cannot be imported at all except in limited numbers by the Department of Agriculture and must then be held in a Federal quarantine house a sufficient time for any disease to develop. There is no restriction on the importation of seed, unless it is known to carry a specific disease, and no safeguards are considered practicable on the entrance of wood, either in the form of logs or in the less dangerous forms of packing cases, paper pulp, etc., though both seeds and wood may sometime bring in destructive foreign diseases or decay organisms. No provision exists for preventing the spread of native forest diseases from East to West or vice versa.

One of the most useful methods in meeting diseases of crop plants is the development of resistant or immune varieties. In a plant with a reproductive period as long as that of a typical forest tree, ordinary plant-breeding procedure is extremely slow. Nevertheless, there is an excellent chance to get results in a reasonable length of time in species which produce seed at an early age or in those in which vegetative propagation can be done readily and cheaply. The introduced willow scab mentioned earlier is a disease which perhaps can be met best in this way. A beginning has been made along this line with poplars for pulp production. Constructive activity against the chestnut blight is also under way in an attempt to develop resistant lines by selecting and hybridizing among the native chestnuts and a large number of Asiatic chestnut types which have been assembled for the purpose. It is obvious that even when resistant strains have been developed, they can be established only in situations where planting is economically practicable.

The constantly increasing use of forests for recreational purposes leads to new concepts of disease and its control. The difference between recreational forest areas and timber-producing areas as to standards for evaluating disease damage has already been discussed. The two types of forest differ quite as much in the needs and possibilities of control. Investigation of the needs and possibilities in the recreational areas has been barely begun, and many of the statements following are to be regarded as tentative. Virulent killing diseases need control in such areas, and protection of the 5-needled pines against the white-pine blister rust is going forward in much the same way as in the commercial forests. For most other types of disease, less attention need be paid to control in extensive stands set aside purely for recreation than in commercial stands. The fact that little or no cutting is done in recreational stands furthermore removes one of the best opportunities for forest sanitation. However, because of the unnatural conditions created by tourist use in the neighborhood of camps, hotels, and scenic attractions, and the importance of the trees in such places, there are unusual local needs for protection, and over small areas methods of prevention or control are justifiable that would be entirely too expensive to employ where timber production is the only consideration. Despite the opinion of some that the dwarf mistletoes add to the picturesqueness of the trees, the owners of recreational areas in several places in the West have undertaken special cutting-out campaigns against them. The spraying or dusting methods developed in orchard work could be employed against unsightly leaf diseases in such places.

The greatest need is for measures that will protect the forest for the campers and sightseers, against the injury that they themselves do to it. Regulations against the careless use of fire and the concentration of trampling and automobile traffic that have partially devastated some of the camping grounds and places of interest are not enough. On the basis of preliminary study of the habits and needs of the tourist, plans have been developed for the laying out of camp sites and other areas where visitors concentrate, in such a way that the tourist will find it most convenient to park his car, build his fire, and do his walking where any damage that may result will be at a minimum. In such special cases as the giant sequoia parks of California, special measures are taken to protect the soil from the compacting that would otherwise ultimately result in the death of the absorbing roots and kill the trees. The fundamentals of tree physiology and root parasitism need further study before the best procedure can be outlined for the different situations that are encountered. In forests in which both timber production and recreation are important, a balanced program of preventive practices needs to be worked out with consideration of both kinds of use.

No disease-control measures are known to have been applied in forests maintained purely for watershed protection, except in the course of the white pine blister rust work in the Northeast, and no other disease is known at the present time to justify direct control activity in such forests.

THE PROGRESS IN FOREST ENTOMOLOGY

By the Division of Forest Insects, Bureau of Entomology

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The progress of forest entomology in this country has been intimately associated with the broader problem of forest protection and to some extent with forest management. The control of insect outbreaks or the prevention of losses from insect attack has been the stimulus for research aimed at accomplishing these ends. Investigation of forest insects and the development of control methods are a function of the Bureau of Entomology; the application of control methods that of the Forest Service and of other land-administering agencies.

IMPORTANCE OF FOREST INSECTS

There is a continuous attrition in our forests from the activities of many different kinds of insects. All stages in the development of the stand, from the seedling to the mature plant, are liable to insect attack at one time or another and in some years even the developing seed crops are destroyed. In virgin timber stands, particularly those which are overmature, a normal loss is going on steadily as the result of insect activity and decay, but such loss for the most part is offset or, in some cases, exceeded by growth. Counterbalancing of growth against loss obviously results in no marked change in the forest capital. On the other hand, epidemic insect outbreaks occurring from time to time definitely deplete the forest capital to such an extent that long periods are required for eventual replacement. For instance the western pine beetle in southern and central Oregon, during the past 10 years, has caused a net depletion of the ponderosa pine stand amounting to 2,240 million board feet. One typical section on the Klamath Indian Reservation carrying a stand of 11,074,000 board feet in 1921, lost 3,875,000 board feet through barkbeetle attack during the period 1921–32. The growth, which was only 48 percent of normal due to drought and a defoliation by the Pandora moth amounted to 294,000 board feet leaving a net loss for the 11 years of 32.2 percent of the stand.

The total losses in the United States from all sources have been variously estimated at $100,000,000 to $150,000,000 a year. This includes depredations by such insects as the mountain pine beetle, the Black Hills beetle, the western pine beetle, the pine butterfly, the spruce budworm, the hemlock looper, the gipsy moth, and losses to the felled log, sawn lumber, and finished wood products in use. A considerable portion of this loss is unavoidable, just as losses from lightning or windstorms are unavoidable. On the other hand, much of it can be prevented and will be so in the future through silvicultural practices, proper management, and direct control.

With mature timber one of the largest single items of loss results from activities of bark beetles. Actual surveys in our western forests indicate that 5 billion to 6 billion feet are destroyed annually by these insects. In lodgepole forests in and surrounding the Yellowstone National Park tremendous losses have occurred. It has been conservatively estimated that during the past 10 years these have amounted to 2,620 million board feet. In one year over 12 million trees were killed. During the last 20 years most of the mature lodgepole forests in regions 1, 4, and 6 have been completely destroyed or are in the process of destruction by the mountain pine beetle. If this is an exmple of what is to be expected in the future, we can assume that lodgepole stands, once they have reached maturity, must be so managed as to be harvested before the beetles play the part of lumbermen.

A recent survey indicates that the forest losses in the State of California due to bark beetles were at least 2¼ times as great in 1931 as they were on an average for the past 10-year period. This average figure has been placed at 500,000,000 board feet. This would indicate a state-wide loss of 1,125,000,000 board feet of merchantable timber. At a purely commercial stumpage rate this represents a loss of nearly $6,000,000, not taking into account the manufacturing value of the lumber, which is an asset going to the region where it is produced. Where these losses deplete the fine old forests that are being preserved as exhibits in the national parks and around recreational areas, they take on a value that is less tangible but undoubtedly much higher than in purely commercial timber.

Defoliating insects likewise destroy considerable bodies of mature timber. These outbreaks, however, usually appear at rather long intervals and are of short duration. An exceptional instance such as that of the spruce bud worm in northeastern United States and Canada ravaged the spruce and fir forests for a period of 10 years (from 1910 to 1920) and it has been estimated that in spruce-fir types of Maine, Ontario, Quebec, and New Brunswick from 40–70 percent of the timber was destroyed and that the equivalent of more than 25 years' pulpwood supply for current annual American paper requirements was lost. Or certain species, even if they do not kill the timber, cause a cessation or reduction of growth which may increase the rotation period of the stand from 5 to 10 years or more. Such defoliations may be local and confined to only a single species of tree or they may spread over enormous areas involving several species. The most recent outbreak of the Pandora moth in the ponderosa-pine stands of southern Oregon occurred between 1918–1925 and covered approximately 400,000 acres. Growth measurements from plots in this area showed that for a period of 11 years the normal forest growth on this area was reduced an average of 32 percent or a loss of increment of approximately 100 million board feet.

The northern white pine is subject to severe insect depredations during the early stages of its growth. The Pales weevil frequently kills a high percentage of the natural reproduction and of the young trees set out in plantations, making it an unsafe practice to do any planting in the vicinity of cutting. After the seedling white pines become well established and until they are 25 years old the plantations and natural stands are subject to severe damage by the white-pine weevil, unless proper precautionary measures are taken. The commercial value of thousands of acres of northern white-pine plantations has been destroyed by this insect, definitely indicating that it is unprofitable to attempt to grow this pine on unsuitable soil or under conditions where some measure of protection is not assured.

It must be clearly understood that these figures for losses include normal as well as unusual drain in the forests. For example, surveys in the ponderosa pine type of California and Oregon tabulate all trees killed by bark beetles. Normally on the best sites but few trees die each year from this cause, say, 30–40 M feet board measure per section, while on poorer sites 50–100 M feet board measure may not be an unusual loss. In lodgepole stands normal losses are practically negligible so that any marked losses indicate abnormal conditions. The same applies to outbreaks of defoliators. They either cause little loss or widespread destruction.

The financial success of certain forest industries such as turpentining of the southern pines may hinge on the attack of insects. Improper methods of chipping result in the attack of a flatheaded wood borer which completely honeycombs the heartwood, lessening the tree's life as a turpentine producer and causing it to break off. Enormous losses have occurred from this source.

Forest plantations are particularly subject to the destructive activities of insects, chiefly because plantations usually consist of large blocks of a single species of tree. Then again many plantations are set out on soils that are not suitable for the species of trees used. Losses in northern white pine plantations in the Northeast and destruction of black-locust stands by the locust borer have, in a great measure, discouraged the planting of these valuable trees. There is a need for more knowledge and forethought in the setting out of forest plantations.

Insect-killed forests are a potential danger because of the existing fire menace. When extensive outbreaks of insects develop in forest types composed chiefly of one species of tree a high percentage of the stand may be destroyed. These standing dead trees go down in the course of a few years making an almost impenetrable tangle of logs and tops. Under proper conditions a flash of lightning may set off the mass resulting in a widespread conflagration almost impossible to fight. Past experience has shown that epidemics of the mountain pine beetle in lodgepole pine have been followed by fires more often than not.

The old snags of insect-killed trees scattered throughout our mature forests, which average for some areas as many as 10 per acre, stand for many years and greatly increase the cost, difficulty, and danger in fire control. Snag felling is required in many sales of national-forest timber, and many private operators have already adopted this regulation. The increased cost of control of fires which have spread from burning snags within fire lines would alone justify insect control even at a high cost.

Such a picture as that presented does not attempt to appraise insect losses in areas of great scenic value. The importance of the forest cover in national parks, game preserves, and recreational areas cannot be estimated in monetary values. Here the esthetic and protective values far exceed that of the commercial timber. Although not so directly appreciated by the visitor one of the greatest attractions in these areas is the forest, as much of the natural beauty of parks, camp sites, etc., is in reality dependent upon a green forest cover. Trees also give protection to the birds and other animals. For these reasons insect depredations which mar the scenic beauty or destroy the protective value of the forest cover must be controlled regardless of cost.

There is another less appreciated aspect of the insect activities in our forests which each year is becoming increasingly important. In some forest types insects often are one of the chief limiting factors in successful management. Insects frequently "throw the monkey wrench", so to speak, into our well organized plans aimed at the production of continuous forest crops. In the western white and lodgepole pine types of the northern Rockies, bark beetles so affect the proportion of species in these stands as to convert the resulting forest into one of entirely different composition, often of inferior species, necessitating an entire reorganization of management plans.

All kinds of forest products from the moment the tree is felled and for many years after the wood is in use are subject to destruction by insects. Insects cause injuries in the living tree which show up as defects in the lumber, thus greatly reducing its value. Green sawlogs and storm-felled timber, green sawn and seasoned lumber, rustic construction, poles, posts, crossties and all manner of finished products from flooring to furniture are attacked. The losses in finished products are particularly heavy in that the cost of manufacture and replacement must be taken into consideration. However, with this type of damage it is much more practical to prevent losses. The most recent attempt to evaluate the losses from this source places the damage at from ½ to 5 percent of the total value of various classes of products.[1]

DEVELOPMENT IN FOREST INSECT CONTROL

Control work against tree-killing bark beetles conducted by three Federal agencies—the Forest Service, the National Park Service, and the Bureau of Indian Affairs—and by private owners as well, has been an important part of the forest protection program in the Western States and incidentally illustrates marked progress in research and administration.

The first project was conducted by the Forest Service in the Black Hills National Forest, S.Dak., in 1906, when $2,700 was expended in an effort to check an epidemic of the Black Hills beetle. Since then many projects have been carried out, some of them covering extensive areas. A total of something over $1,000,000 has been expended through 1931. The annual expenditures from 1906 to 1921 were small—rarely over $20,000 and usually much less. Since 1922, with the fuller appreciation of the importance of the losses brought about through the activities of these insects, increasing amounts have been spent each year for the protection of valuable timber stands. For the past three years the Forest Service has spent from $100,000 to nearly $200,000 annually, the Park Service from $40,000 to $50,000, and the Bureau of Indian Affairs from $10,000 to $20,000.

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[1] Statistical Bulletin No. 21, U.S.D.A.

A candid appraisal of the results secured from the $1,000,000 spent in the control of tree-killing bark beetles has been made by the Bureau of Entomology.[2] In general it can be said that the value of timber saved through this work has been a great deal more than the total expenditures put into control.

Control work has been directed against seven species of bark beetles. Each of these beetles presents an entirely different problem in each forest region and in each forest type. Consequently every project must be considered separately, as attention must be given both to the administrative and to the entomological features. Control methods necessarily must be based upon information regarding the seasonal history and habits of the insects, and also upon certain conceptions and theories, the validity of which can be proven or disproven only by trying out in practice. Early biological studies of these tree-killing bark beetles resulted in the adoption of certain control practices. These methods, although theoretically effective, were admittedly too expensive to adopt under all circumstances and it was recognized that much improvement was desirable. Even now and for some time in the future this type of work will be largely experimental in that uniformly good results cannot be guaranteed until a background of experience is developed. The increasing annual expenditures for control made it possible to experiment with new technique with the result that the present average cost per tree has been reduced by nearly half that of the average cost of a few years earlier.

The so-called "sun-curing method" is used in the control of the mountain-pine beetle in lodgepole pine in the vicinity of Crater Lake, Oreg. This was first tested in 1925 and 1926 and has been applied on an increasing scale up to the present time. It consists of simply felling and limbing the tree, allowing it to lie exposed to the sun for a few days and then turning the other side of the log to the sun's exposure. The cost of treatment per tree in this park was reduced from $1.75–$2 to 40–50 cents, depending on accessibility and seasonal conditions.

Again, with the same beetle in the enormous lodgepole pine infestations in Yellowstone National Park and the surrounding national forests, a method was devised for burning the bark from the trees while standing. This effectively killed the beetles and cost in the neighborhood of 50 cents per tree when it was possible to get fuel oil into the forest by road. The former type of control cost in the same locality averaged $1.50–$2 per tree.

The possibilities of tree medication for the control of bark beetles have been experimentally tested for the past few years. This calls for the injection of chemicals into the sap stream of the tree which in turn will prevent the development of the bark beetle broods and do away with the costly operations of felling and barking or burning the tree. There appears to be much promise in this field but it is yet too early to be confident of results.

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[2] Journal of Forestry, vol. 29, no. 7, November 1931.

A series of tests are under way with certain oils and chemicals which will penetrate the outer bark of infested pines and kill the bark beetle broods. If a cheap material can be developed it will do away with the labor of peeling infested trees and subsequent burning of the bark—two phases of the methods now in use which add considerable to the expense and fire hazard of control projects. Several materials have been tried which promise to be quite effective in producing a kill if applied during the earlier stages of brood development. If the technique of application can be satisfactorily worked out and the cost of materials kept within reason, these experiments should represent a real contribution toward more effective methods and lower control costs.

COOPERATION BETWEEN THE BUREAU OF ENTOMOLOGY AND OTHER FEDERAL AGENCIES IN INSECT CONTROL

It has already been pointed out that forest insect control involves many technicalities based on an intimate knowledge of the habits of the specific insect causing the damage. It likewise involves a detailed knowledge of the topography of the lands under control as well as close contacts with local labor and transportation facilities, which information is only available to the administrative officers on the ground. Due to this combined requirement for technical, entomological, and administrative knowledge, cooperation has been a necessary essential in all past control work.

The responsibility for the investigation of insects affecting forests or, in other words, the discovery of the biological facts on which control rests has been invested by law in the Bureau of Entomology. This law further provides for the cooperation of the Bureau of Entomology with other Federal agencies charged with the protection of Government lands and with private timberland owners. Briefly, the instructions state that the Bureau of Entomology shall be responsible for conducting surveys and for giving specific recommendations for control at the request of other Federal agencies and for the assignment of an entomologist to the project during the period of control when conditions warrant. In actual practice the spirit of cooperation has exceeded the letter of the law. The Forest Service and National Park Service, as well as private owners, have aided the Bureau of Entomology by supplying field expenses or part of the salaries of entomologists engaged in control and the Bureau of Entomology has, from time to time, particularly in the case of the National Park Service, assumed more than its share of administrative duties. The chief handicap to the more successful conduct of such cooperation has been the lack of trained personnel in the Bureau of Entomology.

Another form of cooperation is that involving the joint treatment of intermingled or adjacent lands under different ownership or administrative agency. Insects are no more restricted by ownership boundaries than is fire, hence the necessity for coordinated suppression efforts. This need has been adequately and harmoniously met in the past by all Federal agencies. There is need of greatly strengthening this present effort, particularly by making available funds for coordinated attack when emergencies develop and for more adequate entomological supervision.

FOREST INSECTS AND FOREST MANAGEMENT

Forest entomology is not only a science of protection as emphasized in the foregoing discussion but one of prevention as well. It is obviously better to prevent outbreaks of insects from becoming destructive than to wait until they have gained such momentum as to make direct control necessary. This objective will be attained more fully in the future through proper silvicultural practices applied to the growing stands whereby unfavorable conditions for the development of the insects are maintained or greater resistance of the stand to insect attack is developed. To determine the necessary practices for this form of protection close cooperation between the personnel engaged in other phases of forest research and entomologists of the Bureau of Entomology has been developed at six of the Forest Service experiment stations and certain results have already been obtained.

The reforestation of abandoned farm lands and other waste lands in the Middle Atlantic and New England States has been materially retarded through the activities of the white-pine weevil as already mentioned. Northern white pine, a most desirable and fast-growing tree, has been more extensively used for this purpose than any other species. With the enormous increase in the acreage of susceptible material, the white-pine weevil has increased to such an extent that it has become a serious menace. A thorough study of the problem has indicated that if these plantations are confined to the better sites and the trees spaced not greater than 6 by 6 a profitable crop can be obtained regardless of weevil attack. More recently it has been found that, even in those stands which have been very severely injured, it is possible to carry out certain reclamation practices which will at least give a fair yield from stands which otherwise would be a total loss.

The production of spruce and fir pulpwood in the New England region is intimately associated with the activities of the spruce budworm. Recent investigations have shown that the mortality in various stands following attack of this insect is directly correlated with the vigor and the composition of the stand. In other words, if rapid growth and a low percentage of fir is maintained, the forest will be practically immune.

The woods practices of a decade ago in the naval-stores industry in the South resulted in extravagant losses from dry facing and windthrow. The latter frequently affected such a high percentage of the stand that the crop was abandoned. This windthrow was in a large measure the result of the weakening of the trees by an insect boring in the heart wood of the tree. It gained entrance to the tree through the faces in the turpentined timber. Investigation showed that this loss was preventable through the adoption of conservative practices which at the same time increased the yield of gum and greatly prolonged the period of operation on a given area.

Black locust, a fast-growing tree which has been extensively planted in recent years, particularly on poorer soils, for the purpose of checking erosion, suffers extensively from the attack of the locust borer. In many sections of the country it has been found impossible to secure satisfactory artificial stands. Often the value of the material may be reduced to a point where it is practically useless except for purposes of fuel. On the other hand, natural stands are rarely injured. Recent investigations of this problem, although not yet completed, indicate that the vigor of the individual tree is the most important factor in regulating locust borer damage. Damage occurs in inverse relation to vigor—that is, the more vigorous the tree the less the damage and, furthermore, the borer itself cannot develop in vigorous trees. At present the application of these findings indicates that the solution lies in management through coppice and development of more vigorous strains for planting on waste lands.

For a number of years prior to the conclusion of recent studies the bronze birch borer was by some foresters regarded as a serious forest problem in the management of mixed hardwood stands in northern New England and the Lake States. It is of practically no importance in an uncut forest, except in one which is overmature and where general decadence has set in, but appears in great numbers coincident with the death of the trees left after partial cutting of the original stand. It has been shown that the changes in the physical factors of the environment brought about through the medium of logging are often such that trees left will succumb without the attack of either insects or fungi, and the borer plays only the role of a secondary factor in hastening post-logging decadence.

The application of these studies has indicated that selective logging in any forest which contains a large percentage of birch is a dangerous practice where more than 25 percent of the basal area of a stand is removed. Where cutting is heavier than this, factors of decadence, of which the bronze birch borer constitutes only a minor one, are such that losses will more than offset growth in the period following cutting.

Much progress has been made in recent years toward establishing sustained yield on both Federal and private timberlands in the ponderosa-pine type of California and Oregon. The management of these stands is based on an initial partial cutting, leaving a sufficient reserve of timber for future growth so as to enable a second cutting in from 30 to 40 years. Bark-beetle losses in these stands reserved for future growth have in certain areas not only offset all increment, but have reduced the original forest capital from 1 to 15 percent. Recent experiments have indicated the possibility of avoiding this loss by removing insect-susceptible trees in the initial cutting. These susceptible trees are those of slower growths which can be detected at the time of marking the timber for sale. Recent sales have been marked on this plan.

FOREST INSECTS AND FOREST PRODUCTS

Federal research into the damage and methods of prevention of insect losses to crude and finished products has resulted in great savings to the industry. Losses in this character of material can frequently be prevented by very simple means, such as prompt movement of the felled logs from the woods so as to avoid exposure during the period of insect activity, storing the freshly felled logs in water, or exposing them to direct sunlight during the summer months. At the mill or storehouse prevention can be accomplished by proper inspection, by segregation and classification of the stock of material on hand so as to insure that such material as the sapwood of a hickory, walnut, or oak is not held under conditions subject to attack by powder-post beetles. In the case of materials used in rustic construction, cutting at certain seasons of the year or treating with repellent sprays affords ample protection. Such information has been disseminated through letters and bulletins and personal contacts to such an extent that many mills and operators are fully aware of the possibilities of insect losses and many are adequately guarding against it.

BENEFICIAL FOREST INSECTS

All forest insects are not destructive. There are many species of beneficial insects known as predators or parasites—the former devour the host bodily, the latter usually feed within the body of the host. Occasionally these predators or parasites are the controlling factor in the decline of an outbreak of forest insects. A great deal has been learned about the handling and practical use of certain forms of these beneficial insects, particularly those preying on the gipsy moth. The predators and parasites of this species were introduced from Europe and Japan and established in this country with marked controlling effect on this destructive pest. The pine tip moth was accidentally introduced into the pine plantations of the Nebraska National Forest and for a number of years so retarded the growth of these trees that the abandonment of the use of pines as planting stock was seriously considered. In 1925 a few parasites of this tip moth were collected in Virginia and liberated at Halsey, Nebr. These took hold with remarkable rapidity, and by 1930 had destroyed practically 90 percent of their hosts, effecting satisfactory control of the tip moth. For the past 2 years the effect of this control has been clearly shown in the increased vigor and height growth of the trees. At the present time parasites of several destructive foreign pests such as the larch sawfly, the European pine-shoot moth, and the birch sawfly are being studied in Europe, with the idea of eventually controlling these pests in this country through the establishment of their enemies. There are great possibilities in this field which have hardly been touched.

INSECTS AND FUNGI

The interrelation of insects and fungi presents many interesting technical problems, the solution of which may have a very practical bearing on insect control. For several years the entomologists and pathologists have been cooperating in this field. It has been demonstrated that some of the most destructive species of bark beetles introduce fungi—so-called "blue stains"—into the tree when they attack it, and that these fungi play an important role in hastening the death of the tree and possibly in furnishing conditions necessary for the development of the beetle broods. In at least one case this blue stain alone is capable of killing the tree. It is not going too far to say that a more complete knowledge of the intricate relationships of insects, fungi, and the tree may lead to an entirely different conception of this whole problem and to better control—much as the determination of the interrelation of the mosquito and malaria parasite led to modern prophylactic methods in the control of malaria. There are many such complex interrelations between fungi and insects. For example, the sporadic dying of oaks in the southern Appalachians presents a complex of insects and diseases which we know little about at this time. The same thing has recently been found to exist in the case of dying western white pine in Idaho and Montana, and in California a bark beetle and a fungus are instrumental in the widespread death of Monterey cypress planted for windbreaks, while throughout the Sierras another bark beetle and fungus are causing wholesale destruction of firs. These examples merely emphasize the complexity of the whole problem of forest research and the need of intensive and thoroughly coordinated investigational effort.

CONCLUSION

This brief general picture is intended to illustrate the more important activities of insects in our forests, the development of control methods and preventive silvicultural practices, as well as the dependence on research for continued improvements.

More adequate protection of Government-owned timberlands is desirable: (1) to reduce the losses in merchantable timber; (2) to insure protection of areas of scenic value; (3) under certain circumstances to curtail the development of a fire menace; and (4) to provide better insurance for timber-growing enterprises.

It might be said that fair progress has been made in the past 20 years in the field of forest entomology. For the most part the preliminary work having to do with the discovery, identification, and classification of the important forest insects has been completed. In fact, for many of the important species the life histories and habits have been pretty well worked out as well. However, there is need for a great deal more study into the fundamentals of insect ecology and physiology. We must know more of the interaction of the insects, the tree and the forest, and man's activities in the forest. It is altogether possible that such studies may lead to the prediction of outbreaks and consequent better control or prevention far beyond any possibilities we can see at present.

STATE ACCOMPLISHMENTS AND PLANS

By Herbert A. Smith, Assistant Forester, C. R. Tillotson, District Forest Inspector, and Catherine M. O'Donnell, Law Compiler

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THE DIVERSITY OF STATE POLICIES OF FORESTRY

The forest policies of the several States are conspicuously diverse. They differ not only (as would naturally be expected) regionally, in consequence of having to face unlike problems, or because of differences in wealth and resulting capacity to undertake public enterprises for the general welfare, or on account of different traditions and conceptions regarding the proper field of government; they differ also in States of substantially identical problems, comparable capacity to meet them, and generally similar traditions and practices in the matter of government. Yet State forestry has not been evolved by each State independently. The development of these varied policies and programs has taken place in integral connection with the general forestry movement, which has been national in character.

The clue to many of the dissimilarities in the approach of different States to essentially similar problems, and in the degree of progress made, can be found only by tracing out the history of the forestry movement in each State. Much has been due to accident, and much to the personality and aggressiveness of individual leaders or opponents. The state of public sentiment and the attitude of the press have of course been important. The essential point to bear in mind is that, if the future is to be judged by the past, uniformity of action should not be looked for, even where substantially identical situations have to be dealt with.

Unquestionably, however, the present diversity of State forest policies would be enormously greater had it not been for the effect upon the States of Federal activities and policies. Indirectly, Federal forestry has had a pronounced influence by force of example and suggestion. Directly, it has done much both to stimulate action and to determine the line of action, through cooperative and other aid.

DIVERSITIES WITHIN REGIONS

The individuality of State forest policies comes out when States in the same general region are compared with one another. Some of the more striking contrasts which are revealed in the northeastern States will serve for illustration.

The three northern New England States are predominantly rural and have a high percentage of their area in forest. In Maine, forests occupy 76 percent of the land area; in New Hampshire, 77 percent; and in Vermont, 55 percent. State forestry in Maine is almost entirely limited to protection. Most of the forest area of Maine is in the so-called unorganized towns—that is, the wilderness part of the State. From 70 to 75 percent of the total cost of maintaining the fire-protective system is provided by a special tax levied on property most of which lies in these unorganized towns; virtually, therefore, Maine goes on the principle that the property protected should bear most of the burden. The State does not do much to aid private forestry through investigation and advice except that it is outstanding in its investigations of forest insects and advice for their control. Its forestry activities head up in a commissioner of forestry, who is also in charge of the handling of all the State's lands. The commissioner is appointed directly by the governor, for a 4-year term, and need not be a technically trained forester. Nor, in point of fact, is there any strong reason why he should be, with the field of activity what it is in Maine. It is nevertheless noticeable that of his yearlong force 13 are technical men and only 4 nontechnical. The total 1931-32 appropriation of the department for all purposes is at the rate of 1.34 cents per acre for all the forest land (other than Federal) in the State, and more than 91 percent of the total is for protection against fire, disease, and insects.

In New Hampshire and Vermont, while the law in neither case requires that the head of the forestry department shall be a trained forester, the positions are filled by trained foresters, and it is pretty safe to say that they always will be, for the scope of the job recognizedly calls for a technical forester. In Vermont the commissioner of forestry is appointed for a 2-year period by the governor, with the advice and consent of the senate. In New Hampshire the State forester is responsible to a commission consisting of three members, appointed by the governor, with the advice of the council, for overlapping 3-year terms. New Hampshire has nearly 33,000 acres in State forests under administration, and Vermont nearly 41,000 acres. In New Hampshire the acquisition of further land for State forests is at present in abeyance, and there is no definite program for building up a larger State forest system. In Vermont the continuation of purchases is intended, subject of course to the condition of the State's finances, up to 100,000 acres. In both New Hampshire and Vermont the maintenance of the fire-protective system is regarded primarily as a public function. The New Hampshire laws, however, provide for patrol by private owners of 1,000 acres or more of forest land in any one town or unorganized place, and the Vermont laws provide for assessing a part of heavy suppression costs against owners of unoccupied or unenclosed lands unless these lands had been given protection by their owners. Out of a 1931–32 annual forestry appropriation of $77,250, New Hampshire made available for fire protection 36 percent, equivalent to a per acre protection expenditure of 0.65 cent, not including a Federal allotment of $18,012. Vermont's funds for fire protection are 29 percent of its total appropriation of $54,117, equivalent to 0.46 cent per acre of forest land protected. Including funds for protection against insects and tree diseases, 58 percent of the New Hampshire total appropriation was for protection, as against 33 percent in Vermont. The functions of the State foresters in both New Hampshire and Vermont embrace research, extension, and general education. By "extension" is meant services of practical assistance and advice to private forest owners to extend the practice of forestry.

In contrast with northern New England, southern New England is highly industrialized and much more densely populated. But while there are no extensive areas of wild lands in large ownerships, as is the case in Maine and to a less degree in New Hampshire, there are portions of all three States in which there is relatively little industralization and in which, also, the major part of the land is unsuitable for agriculture and is in forest. The most extensive area of this kind is in western Massachusetts, which is broadly comparable to the Vermont Green Mountain country northward of it. The land-purchase program of the Massachusetts Forestry Department has been largely concentrated in this section of the State. Of the total area of Massachusetts, forest lands make up 63 percent; of Connecticut, 51 percent; and of Rhode Island, 41 percent. Were the western part of Massachusetts to be considered separately, it would show a percentage of forest land to all land more nearly approaching that of New Hampshire. While somewhat different forest policies might be expected in southern New England from those in northern New England because of differences in their forest conditions, the major consideration is the greater wealth of these States and their ability, consequently, to engage in public undertakings of a larger scope, if they are held to be important for the State's welfare.

Certainly Massachusetts presents a strong contrast to New Hampshire and Vermont. With a forest area about equal to that of Vermont and about 25 percent less than that of New Hampshire, Massachusetts appropriates for its forestry work more than five times as much as New Hampshire and nearly eight times as much as Vermont. More than one half this total is for the maintenance and improvement of the system of State forests, which at present have a total area of 120,000 acres, with the prospect of an increase under the present policy of the State to 150,000 acres. The present State forests form 3.7 percent of the total forest area, and the contemplated eventual 150,000 acres will form 4.6 percent. Connecticut, however, with 3.9 percent of the total forest area now in State forests, contemplates their increase to 15.8 percent. On the other hand, Rhode Island has made the merest beginning toward a State forest system, if it can be called a beginning, with 410 acres now so classed, and no definite program of further acquisition. Rhode Island's total expenditures on her forestry work from State appropriations is equivalent to 8.7 cents per acre of forested land; Connecticut's, 11.6 cents; Massachusetts', 13.1 cents. While Rhode Island has had a commissioner of forestry or similar officer since 1907, the position has never been filled by a technically trained forester. With substantially the same basic reasons for a policy of forestry as exists in Connecticut, the interest in Rhode Island has been slight relatively, and progress until recently exceedingly lagging.

The commissioner of conservation in Massachusetts is ex-officio State forester. He is appointed by the Governor, with the consent of the council, for a 3-year period. He appoints his subordinates from a civil-service register. Fire suppression is a function of town wardens, who are nominated by the selectmen of each town and, if satisfactory, are appointed by the State forester. The towns shoulder the entire cost of forest-fire suppression.

In Connecticut the State forester is chosen by a commission of seven members, six of whom are appointed by the Governor, with the forester of the Connecticut Agricultural Experiment Station serving ex officio. The State forester hires such assistants as the commission judges necessary. He chooses his own fire wardens without reference to the towns, pays all initial costs of fire suppression, and charges half of it back to the counties in which the fires occurred.

Space forbids going into any such detail regarding the dissimilarity of forest policies outside of New England, when States in the same general region and with the same general problems are compared. All that need be done is to point out swiftly a few striking examples.

For the first example, a comparison of New York, Pennsylvania, and New Jersey may be made. In both New York and Pennsylvania the acquisition and administration of forest lands has been the leading State activity and the most outstanding part of the forest policy from the time that these States began to have a forest policy—and in both cases that goes back into the nineteenth century. New Jersey, on the other hand, has had no acquisition policy at all comparable in scope or purpose until within relatively recent years. The acquisition policy of New York, however, has had chiefly in view the protection of the scenic, recreational, and water resources embraced in the Adirondack and Catskill Mountain regions; and to safeguard fully the forests of the State-owned land in these regions, New York has considered it wise to write into its constitution a provision specifying that no timber on the State lands within the Adirondack and Catskill Parks may be sold, removed, or destroyed. Pennsylvania embarked on its acquisition policy to bring back to productiveness at least a part of the great area formerly covered with fine forests which had become worthless through forest devastation, and aims to grow commercial timber on these lands, now amounting to about 1,600,000 acres. New York is unique, also, among all the States in the fact that she has lately adopted a policy of acquisition to take over and reforest abandoned and submarginal farm lands, at a total cost of $20,000,000.

Again, we may compare Maryland, Virginia, and West Virginia. Maryland and Virginia have both for a long term of years maintained State forestry departments headed by technical foresters, with fire protection as their primary duty but with extension and general informational and educational activities also included. In addition, Maryland entered on a policy of acquisition in 1906 and now has in State forests under administration approximately 50,000 acres, as against 588 acres in Virginia. Maryland, with a total forest area of 2,200,000 acres, appropriates annually for its forestry work more than $90,000; Virginia, with 15 million acres, a little more than $39,000. West Virginia, with 10 million acres of forest land, places its forestry work in a department presided over by the State fish, game, and forestry commission, and finances it by making available 25 percent of the receipts from fish and game licenses. Public sentiment throughout the State regarding a program of forestry beyond fire protection appears to be rather apathetic, and not particularly aggressive even in the matter of protection outside of a limited group of large landowners. Until 1929 the State did not have its forestry work handled by a technical forester, except that an extension forester was and still is provided by the extension service of the State Agricultural College. While 15,393 acres are classed as embraced in State forests, the land was acquired primarily for game protection, a few years ago, and there is no program contemplating further acquisition. In comparison with either Maryland or Virginia, West Virginia has not paid much attention to forestry.

DIVERSITIES BETWEEN REGIONS

There are broad distinctions of forest policy that mark off from one another groups of States having unlike conditions, natural or economic. They will come out in detail as the accomplishments and present status of State forestry are outlined. The character of the differences may be illustrated here by comparing briefly the situations in the Northeast, the Lake States, the South, and the West.

In the Northeast, State forestry has long been firmly established. Public opinion in its favor was created by the rapid cutting off of the original forests as the nineteenth century advanced; the accompanying and following devastation wrought by uncontrolled fires; the increasing dependence of the region upon the Lake States and the South for lumber and other forest products; the wood requirements of the many and growing industries, and of an increasing industrial population; and the scenic and recreational values in the Adirondack, Catskill, White Mountain and other regions. This favorable sentiment was strengthened by the unquestioned belief that deforestation would have revolutionary effects upon the climate of the region as well as upon streamflow and water supplies generally, that navigation and power were already affected, and that the actual wiping out of the forests was under way. Scientific thought played a large part in arousing and shaping public opinion; scientists were conspicuous leaders in the early forestry movement, especially in the Northeast. While considerations of sentiment were undeniably also an influence, economic reasons furnished the chief impulse for public forestry.

Timber was plainly the only feasible crop for much of the land. The acreage under cultivation was shrinking, the forest area gaining. The richer States were financially able to undertake enterprises of public forest ownership without difficulty. Even the safeguarding of mountain scenery against the unsightly results of destructive lumbering and fires had a strong economic motive. In New York the perpetuation of the Adirondack forest was considered essential for the water of the Erie Canal, and important for the navigation of the Hudson. In New England many manufacturing enterprises were dependent for power on the rivers fed from the White Mountain region. Pennsylvania was deeply concerned over the fast increasing amount of denuded land which was gaining for itself the name of "the Pennsylvania desert."

So forestry in the Northeast got off to an early start. In New York and Pennsylvania, policies of State forest ownership came to the fore at once. As technical foresters became available and the forestry movement grew stronger throughout the country, most of the other States created forestry departments, which at first were set up principally to inform and advise forest owners on forestry practices and to gather information on the forest resources and forest needs of their several States, but which soon began to take on administrative duties of fire control, followed more or less shortly in a majority of cases by the first steps toward building up State forests. While some of the Northeastern States have relatively little to show in forestry, the region as a whole is outstanding in the strength of its organizations, the financial support given them, and the scope of their programs. In recent years, provision for the outdoor recreational needs of a highly industrialized and populous section of the country has come to occupy a larger place in the plans and activities of the forestry departments than was contemplated at first.

In short, the early exploitation of the virgin stands, the large amounts of second growth, the extent of the forest lands unusable for other purposes than timber growing, the importance of local timber supplies to meet expanding industrial and construction requirements, the recreational needs of a large and growing urban population, the importance of water, the length of time during which public forestry has been under way, and the wealth of most of the States, making relatively liberal public expenditures for forest purposes easy, explain why in the northeast forestry stands high and policies of State forest ownership and administration are further developed than in any other region, with a total of nearly 4,500,000 acres in State forests and parks.

In the Lake States, also, forestry got off to an early start, but with less success. The terrific forest fires of 1894 were followed the next year in both Minnesota and Wisconsin by provision for a chief fire warden, and in 1899 Minnesota set up a State board of forestry and Michigan a forestry commission. Unlike the Northeastern States, however, the Lake States at the turn of the century were still in the hey-day of lumber production from the enormous virgin stands of the region. While there was a considerable body of public sentiment in favor of forestry, the era of timber exploitation and land development gave rise to powerful antagonistic forces. Minnesota enacted legislation in 1903 authorizing the forestry board to purchase lands for forest reserves; but virtually nothing was done. Local sentiment in the heavily forested counties preponderantly and strongly favored cutting the timber off, in expectation that the stump lands would be converted into farms and for the sake of the immediate returns from lumbering. In Wisconsin, for a few years, a substantial and very promising program of State forest acquisition and administration was entered upon, only to be suspended. In all three States until within the last decade, the building up and maintenance of systems of protection against forest fires has been the principal concern and accomplishment of the forestry departments. Periodically recurring seasons of exceptionally severe fire hazard and losses drove home the necessity for protection and strengthened the public demand for it. Protection was no less in the interest of the lumber industry and timberland owners, so long as their manufacturing equipment and stands of virgin timber remained exposed to destruction by fire, than it was in the interest of future forests.

As the Lake region has been brought face to face with the stern economic realities of the outcome of timber exploitation in sections where extensive agricultural development is impossible, there has been a great awakening. It has been realized that private ownership of heavily timbered lands induced by the profitableness of cutting the timber off must be only temporary if the stripped forest land cannot be put to use. High-pressure efforts to sell stump land to would-be farmers have demonstrated the unfavorable economic and social results of trying to build up agriculture where it cannot in the long run afford the farmer and his family a livelihood. Many millions of acres of cut-over land no longer worth paying taxes on are returning to public ownership in the Lake region through tax forfeiture. Thus a gigantic problem of land utilization is the outstanding feature of the present regional situation.

All three States are now grappling with it and have inaugurated far-reaching policies of retention, acquisition, reforestation, and permanent public administration of nonagricultural lands. Next to the northeastern region, this is the region in which State administration of forests has made greatest progress. The area embraced in State forests (or in Wisconsin, for special reasons which will be brought out later, partly in State and partly in county forests) in the three Lake States is over 1,900,000 acres, but the development of their administration is as yet, for the most part, far behind that in the northeastern group of States and for much of the land is embryonic. The Lake States are financially handicapped, in comparison with the Northeastern States which have assumed large responsibilities of forest land administration, by their much smaller tax base. For example, the total assessed property values per square mile in the three Lake States are only about one fourth those in New York and Pennsylvania, or on the basis of forest area alone—that is, if the total assessed values be divided by the number of square miles of forest—only about one fifth.

In the South most of the growth of State activities in forestry has taken place during the last 10 years. In 1920 only Virginia, North Carolina, Louisiana, and Texas had forestry departments. Tennessee was added in 1921, and Alabama in 1923. There is now a forestry department in every Southern State but one (Arkansas). The main objective in all cases is the control of forest fires. There has not as yet been developed in any of these States a policy looking to the creation of a system of State forests, and almost no State-owned lands are under forestry administration. While nearly every State now has a technically trained State forester, and while the duties of the position include the promotion of forestry through advice to private landowners and through general informational and educational activities, there is little time or money available for other purposes than maintaining the protective organization and arousing public sentiment against fires.

This is not to be wondered at. While exploitation of the virgin timber stands of the South is now far advanced, the region did not become the major lumber producing region of the country until shortly before 1900. Prior to 1890 the cut was too small to make a material inroad on the standing timber. The harvesting of this tremendous accumulation of potential wealth has been a main contribution to the economic development of the South since that time. As in other regions, timber exploitation had to run most of its course before the public became concerned over the fact that exploitation could not go on forever and that where the merchantable stand had disappeared and the great mills shut down for lack of logs, the communities built up around them would melt away. There was no fire menace of the kind that existed in the Lake States, and surface fires to clean off the dead grass and forest litter and keep the forest open were regarded as beneficial rather than harmful. The South had neither the taxable property values nor the viewpoint with respect to the functions and possibilities of the State government as an agency for furthering the general welfare along new lines to be readily inclined to set up forestry departments. All the habits and traditions of a predominantly agricultural, rural, individualistic, and in some respects still almost pioneer stage of economic and political development tended in the direction of a "hands-off" attitude and a lack of any great concern about conserving the sources of future wealth through public action.

The offer of Federal cooperative funds to aid in fire protection has proved a strong influence toward the inauguration of forestry work by a majority of the Southern States since the enactment of the Clarke-McNary law in 1924. The tasks requiring first attention were to build up a protective organization and also a better informed public sentiment on the value of the forest resource, the importance of taking care of it, and the harmful consequences of fire in the woods. Thus the educational—it might almost be termed the missionary—function of the new State departments has loomed large, much as it did a quarter of a century earlier in the North. It has been necessary to convert the rural mind to a changed conception of what is good for the forest, the forest owner, and the community. In default of liberal State appropriations to maintain extensive systems of protection the State foresters have had to depend in major part upon the willingness of private landowners to contribute funds that in turn would bring Federal cooperative contributions. Thus the field, organization, and objectives of the forestry work in the Southern States are in many ways differentiated from those which are characteristic of the work either in the Northeast or in the Lake States. The South, however, faces the approach of a situation essentially like that in the Lake States, through the abandonment of very large amounts of cut-over land which the private owner does not consider worth paying taxes on.

In the West, the development of State forestry has been very greatly affected by the presence of the national forests, which embrace more than one half of the commercial forest land of the region (though by no means a corresponding amount of the merchantable timber, since the private holdings as a rule have the better and more accessible stands). Naturally, Federal administration of so large a part of the western forest land makes State policies of forest ownership and administration much less urgent than they would otherwise be. The principal objective of the early State forestry movements in Colorado and California was to provide an agency for safeguarding the interests of these States in the preservation of the public domain forests; and after the Federal Government entered upon the task those who had led in the State movements were more than satisfied to have the State interests so taken care of. At the same time, national forest administration has been a positive influence for the development of State forestry policies, as well as a means of meeting many of the needs which in the rest of the country have placed heavy responsibilities upon the States.

Outside of Colorado and California, the inception of State forestry activities in the West was an outgrowth of the need of timberland owners to obtain organized protection against forest fires in regions of high exposure and great investments in stumpage. First the timberland owners organized protective associations as a private activity, on a voluntary membership basis; then, to make their protection more effective, they sought the aid and authority of the States to extend the system to intermingled and adjacent lands, State and private, which needed to be covered along with the association lands. Under the resulting set-up most of the cost of protecting the private timber holdings is met by the owners, with the assistance of Federal cooperative funds; and the protective organizations are built up and run mainly by the associations. They work in close touch with the national forest protective organizations and have taken over from the latter the methods developed by the Federal Forest Service applicable to their own undertaking. This general scheme of organization particularly characterizes the Northwestern and Pacific Coast States. In certain of the other Western States, the Federal protective system is directly utilized by the States under cooperative agreements with the Forest Service to cover State and private lands along with national forest lands, as a single undertaking.

There is also in the West an important development of State forest land administration, due largely to the example of the national forests combined with the fact that a few States still have in their possession large acreages of forest lands received through Federal land grants. Most of the granted lands were originally scattered, but by exchanges of their school lands within the national forests for solid blocks of timberlands made available for their selection under exchange agreements, Montana, Idaho, and Washington have obtained nearly 800,000 acres suitable for permanent administration as State forests and likely to be so administered. This situation will be further explained and discussed later; the point to be noted here is that, in the West hitherto, granted lands in the possession of the States have been the chief cause of the beginning of a system of State forests. The necessity for State policies to meet the problem arising from an extensive breakdown of private ownership following the cutting off of the original timber is only beginning to present itself definitely, but is likely to bring about results in several States similar to those in the Lake States at the present time.

THE ORIGIN AND DEVELOPMENT OF STATE POLICIES OF FORESTRY

The history of State forestry throws much light on what can reasonably be expected of it.

HOW STATE FORESTRY STARTED

A widespread interest in forestry and demand for some form of public action on its behalf developed in the United States in the third quarter of the nineteenth century. The extensive interest in forestry which led to the inauguration of public effort for its promotion both in many States and by the National Government is shown by the following list of significant developments prior to 1885:

1819. Massachusetts law to encourage the growing of trees necessary for ship building by means of premiums to be offered by the agricultural societies receiving the bounty of the State.
1837. Massachusetts provided, in connection with a geological and botanical survey of the State, for a special report on the native trees and shrubs, keeping in view economic relations and particularly the agricultural and general benefit of the commonwealth by leading landowners to engage in forestry.
1846. Massachusetts report on the forest survey of the State published.
1861. Nebraska Territory law to encourage forest planting through tax exemption.
1867. Wisconsin law for a commission of three to inquire into the rate of forest destruction and its climatic effects, whether the State should regulate private forest practices, and what the State should do to preserve the forests and encourage their return.
1868. Iowa law to encourage forest planting through tax exemption.
Kansas law to encourage forest planting through bounty.
Wisconsin law to encourage provision of natural or planted timber belts through tax exemption and bounty.
1869. Dakota Territory law to encourage the artificial establishment of timber growth through tax exemption.
Nebraska State law to encourage forest planting through tax exemption.
Maine State Board of Agriculture appointed a committee to present to the legislature suggestions regarding the expediency of a State policy for the preservation and production of forest trees, and to call the attention of Congress to the same subject.
1870. St. Paul & Pacific Railroad began forest planting.
Kansas Pacific Railroad began experimental forest planting.
Missouri law to encourage forest planting through bounty.
1871. Minnesota law to encourage forest planting through bounty.
1872. Nebraska began observance of Arbor Day to encourage forestation.
Burlington & Missouri River Railroad began forest planting.
Maine law to encourage forest planting through tax exemption.
New York created a commission to investigate the expediency of establishing a forest preserve in the Adirondack region.
1873. Atchison, Topeka & Santa Fe Railroad began establishment of forest nurseries with a view to timber growing.
Federal Government passed the "Timber Culture Act" to encourage forest planting on the prairies through bounty in form of land.
Nevada law to encourage forest planting through bounty.
American Association for the Advancement of Science created a committee "to memorialize Congress and the several State legislatures on the importance of promoting the cultivation of timber and the preservation of forests," and to recommend legislation.
New York State commission recommended the holding of tax-delinquent lands in the Adirondack region to build up a State park.
Committee of the American Association for the Advancement of Science memorialized Congress for the appointment of a Federal commissioner of forestry, to prosecute investigations and inquiries.

1874. Illinois law authorized counties to offer bounties for forest planting.
1875. Idaho Territory law to encourage forest planting through tax exemption.
1876. Minnesota made an appropriation to promote the objects of the Minnesota Forest Association, which offered premiums for tree planting. Reports showed 10 million trees planted in 1876 and estimated 1877 planting of another 10 million.
Colorado constitution provided that the legislature "shall enact laws to prevent the destruction of, and to keep in good preservation, the forests upon the lands of the State, or upon lands of the public domain the control of which shall be conferred by Congress upon the State."
Colorado constitutional convention memorialized Congress reciting the calamitous consequences of forest destruction, the lack of Federal protection of, care for, or interest in the forests of the public domain in Colorado, and the need for forest planting in the treeless parts of the State if it were to be redeemed for agriculture and populated; and praying that the State be given control not only of "all the Government forests on our mountains but also at least one fourth of all the Government lands on our plains."
Federal law passed inaugurating provision for forestry investigations in the United States Department of Agriculture—the origin of the present Forest Service.
1877. Southern Pacific Railroad undertook experiments in tree planting.
Washington Territory law to encourage forest planting in two counties in the treeless portion of the State through tax exemption.
Wyoming Territory law to encourage the artificial establishment of timber growth through tax exemption.
Recommendations by the Secretary of the Interior that all public domain timberlands be permanently reserved and placed under administration for forestry purposes.
Connecticut made provision for an inquiry and report upon forestry.
Connecticut law to encourage forest planting through tax exemption.
1878. Massachusetts law to encourage forest planting through tax exemption.
Rhode Island law to encourage forest planting through tax exemption.
1879. Nebraska law to encourage forest planting through bounty.
1881. Colorado exempted from taxation increased value of irrigated lands due to tree planting.
New Hampshire created a temporary commission of inquiry.
1882. Vermont created a temporary commission of inquiry.
Massachusetts authorized towns and cities to establish municipal forests.
New Mexico Territory law to encourage forest planting through tax exemption.
1883. New York law prohibited further sales of State lands. (Through acquisition under tax sales the State holdings had risen from less than 40,000 acres in 1873 to more than 700,000 acres.)
1884. New York appointed committee of experts as a commission of inquiry.

This list shows—

(1) That shortly after the Civil War a very general belief prevailed that public action was needed on behalf of forestry.

(2) That the major objective during this period was to promote forest planting (then often called "timber culture", "tree culture", "forest culture", and even "forest orcharding").

(3) That the interest in this was keenest in the prairie region, but was by no means absent in the eastern part of the country where the natural timber growth was originally everywhere abundant.

It is worth while to ask what were the impelling forces back of the forestry movement in its formative period.

REASONS FOR WANTING PUBLIC FORESTRY

Sixty years and more ago fear of an impending timber shortage and a supposition that the forests of the country were being very rapidly swept away were widely prevalent. Local shortages had actually developed, at various times. About the beginning of the nineteenth century, for example, a dearth or near dearth of wood supplies seems to have been experienced in many communities.

Until the railroads had spread over the country and had pushed their ramifying lines into the smaller towns and rural localities, the question of wood supplies was likely to turn on the amount available by team haul, over poor roads. Wood cannot stand costly transportation without formidable enhancement of its price. Until coal came into general use, for both industrial and domestic purposes, the requirements for fuel alone were enormous. Even in the very early days of colonial settlement local inconveniences from the depletion of supplies near at hand were sometimes felt. Throughout the nineteenth century the expressions of concern and alarm over the rate at which the forests were being cut, the havoc that was being wrought by forest fires, and the wastefulness with which timber was utilized were recurrent and insistent. Relatively few people seem to have disputed the popularly accepted belief that failure of timber supplies was approaching rather rapidly.

It is often said that frontier life bred hostility to the forest and that this soon became the dominating American attitude. It may nevertheless be questioned whether there was ever a time when many people did not regret seeing the forests wiped out or devastated, on grounds other than utilitarian. Certainly in the decade of the seventies one of the motive forces behind the forestry movement was the belief that a well-wooded country is more habitable and more attractive than one without forests. Another and more powerful impulse behind the forestry movement was the conviction that forests not only made stream flow more equable and prevented erosion and floods but also exercised a very important influence upon the climate, ameliorating its extremes, increasing its salubriousness, and adding to the rainfall. That forest denudation brought marked changes in the behavior of springs and streams had long been a popular belief based on common observation. Shortly after the middle of the nineteenth century public solicitude for forest preservation and forest extension as a means of controlling floods and beneficially affecting climatic conditions was greatly increased by influences from abroad.

In Europe the consequences of the destruction of forests following the French Revolution were awakening alarm; and Americans who had been brought into contact with foreign observations and conclusions on the subject began to make them known in this country. Outstanding in its influence upon American thought in this field was the publication in 1864 of George P. Marsh's "Man and Nature", revised and republished 10 years later under its better-known title, The Earth as Modified by Human Action. The agitation that was going on in France and Italy over the serious effects of deforestation upon stream flow in the Alps and Pyrenees and the conclusions of contemporary European scientists and geographers on radical climatic changes as a result of the destruction of tree growth in countries bordering the Mediterranean became a powerful influence upon American thought.

The westward march of the frontier across the prairies brought another influence to bear. The settlers in the treeless country missed the forest to which they had been accustomed. They eagerly took up tree planting, to make the country more habitable and homelike. Still farther west irrigation was important. Soon the idea became generally accepted that the semiarid plains region, popularly included in the "Great American Desert," must be made habitable for civilized man and reclaimed for agriculture, if it was to be reclaimed at all, by means of tree planting on a gigantic scale. Thus, it was thought, the climate might be changed and the rainfall so increased as to alter the character of the whole region agriculturally.

WHY THE EARLY MOVEMENT ACCOMPLISHED LITTLE

The widespread interest in "timber culture" or "tree culture" and the efforts to promote forest planting through public encouragement and assistance did not turn into new channels the earlier current of thought regarding what forestry should primarily be concerned with in the United States. Even today, in the popular mind, the inauguration of forestry tends to be thought of as tree planting. That forestry should as a rule concern itself with established forests and that the application of silviculture is accomplished mainly through skillful utilization, which controls and directs the later growth of the forest, is a conception not readily grasped by the average man. In the seventies of the last century even those best informed on forestry and most active on its behalf gave surprisingly little attention to the possibilities of forestry as a substitute for the current practices of utilization. One reason for this was the fact that the chief early agencies seeking to promote forestry were agricultural and horticultural societies. Another was that the scientific knowledge necessary for the application of silviculture to American forests was completely nonexistent. A third was the tendency among early leaders of the forestry movement to assume that the old forests were doomed and if there were to be future forests they would have to be planted and grown, like other crops.

The very considerable effort made on behalf of forestry prior to 1885 accomplished little of permanent importance, in spite of the strong moving forces back of it, partly because of inadequate knowledge and fallacious conceptions, partly because the forms of governmental organization then established provided no suitable machinery for the kind of undertakings required. That the climate of the semiarid regions could be profoundly altered by inducing settlers to engage in "timber culture", and that if the desert were to be reclaimed for agriculture it must be by means of extensive afforestation, were of course complete misconceptions. But irrespective of whether the objectives of the forestry movement in its early stages were right or wrong, their achievement was impossible because the people of the United States had not then gone far in developing the capacity of government to meet the needs of a complex, highly organized economic life. In the latter half of the nineteenth century the field of government had to be broadened in many directions. To assume the new duties, new machinery had to be set up. The creation of the machinery necessary for the successful conduct of public activities in forestry proved a slow process—indeed, it is even now unfinished.

EARLY FEDERAL FORESTRY MOVEMENT

Before taking up the development of State forestry from 1885 on, it is necessary to bring within the field of vision what was beginning to be done by the Federal Government; for this was to have a very great influence upon the States.

The year 1876 saw the first provision made by Congress for the inauguration of forestry work as a Federal activity. It was also the year in which the first Western State asked Congress to turn over to it the timberlands within its borders. In the following year the proposal was first submitted to Congress that it should reserve and place under administration the timberlands of the public domain.

It will be recalled that the legislation authorizing the Department of Agriculture to conduct investigations in forestry and making an appropriation for this work had been sponsored by the American Association for the Advancement of Science. The law brought into being a small bureau of inquiry and information. No important departure from past policy, no commitment of Government to a new kind of activity, was involved in that. Nor was the request of Colorado that the public timberlands within the State be made over to her a proposal of an essentially new Federal policy. To dispose of the public lands, in one way or another, had always been the basic policy of the Federal Government, and for that matter of the States too. But the idea of the Government's undertaking permanent forest management was a bold and astonishing departure. It did not originate with those who had been previously active on behalf of forestry. Not only did it come from outside their number; it proposed a kind of public activity which some if not all of them had regarded as wholly out of the question.

There was every reason to hold it so. It flew in the face of accepted ideas regarding the functions of the Federal Government. It involved a reversal of the course which had been pursued with respect to the public domain from the foundation of the Union, and conflicted with the whole American tradition of individualism and preference for private property ownership. And it proposed the assumption by the Federal Government of a kind of public undertaking for which it was not only manifestly unequipped but also manifestly at that time unfitted. Moreover, it brought the proposal forward at a time when the inherent weakness of the political system as then evolved for taking on duties that called for integrity, long-range stability, and expert administration stood shockingly revealed.

The scandalous frauds and open pillage which had been commonly practiced under the public land laws were well known. They had been freely set forth in the annual reports of the Interior Department. The corruption which had invaded public life and besmirched public officials of the highest rank, involving not only members of the executive and legislative branches of the Federal Government but also of the judiciary, had been freshly and startlingly exposed. It is doubtful if there was ever a time in the history of the Republic when the morale of government was at a lower ebb and public distrust of the ability of government to serve the public welfare with fidelity, consistency, intelligence, and disinterested enterprise was deeper or better grounded. Secretary of the Interior Carl Schurz originated and brought forward what was eventually to become the national forest policy at a singularly unpropitious time. Its immediate adoption could only have been followed by disastrous failure. Government was unprepared to assume the responsibilities involved and would have been incapable of discharging them acceptably. Nor was the proposal of State ownership and administration of the forests of the public domain much more promising. In the long run, the Colorado plan would have failed had it been adopted; and as the matter finally turned out, would have failed irretrievably. Inaction for a time finally saved the day.

Some of the reasons why permanent public retention and administration of the public-domain timberlands could not be expected to work were pointed out in the opening pages of the first Report upon Forestry published by the Agricultural Department. Under the spoils system of political appointments the civil service of the Federal Government was made up of a changing body of officeholders selected on other grounds than merit and special qualifications for the duties to be assumed, and dependent for their term of office tenure, as for their original appointment, upon their political backing. Each change of administration brought into office a new horde of untrained, inexperienced men to supplant those already filling the positions regarded as the reward of victory and the plums of the political tree. There were no trained foresters in the United States, and no educational institutions which could provide even the most elementary training in the profession of forestry. There was no knowledge of the technique and practice of forestry, and the beginning of the necessary basis of scientific knowledge were not in sight.

> We have no inducements—

the 1877 Report upon Forestry set forth—

> to offer a young man who might aspire to a position for which he might have great native ability, and for which he would be willing to undertake the most thorough special education if he felt assured that employment would depend alone upon the most thoroughly approved preparation, or the most rigid examination. Hence it cannot, at least at present, be expected that our governments can undertake the practical management of forests, as is done in Europe, by officials specially trained for this pursuit, with the view of deriving a benefit from the cultivation. They can scarcely do more than prevent depredations upon the timber already growing, if, indeed, they can succeed in this, * * *.

The Federal Department of Agriculture, which had been giving more or less attention to the subject of forestry in its publications prior to the time when Congress, in 1876, inaugurated the work as a permanent activity of the Department, had brought out a paper in 1866 which presented in strong terms the urgent necessity for prompt action to conserve and renew the forests of the country, and advanced a plan for systematic experiment and research to find out how to manage forests and how to establish successful and paying plantations. The author held that this—

> should receive the immediate attention of our Government, and enjoy its fostering care.

But—

> the experiments, to be of any value, must be continued through several Presidential terms; and in the continual changes * * * no one person would be permitted to control these experiments, to carry out to completeness thoroughly digested theories and test them in actual practice, and to avail himself of his own experiences. * * * The liability would be a defeat, through incompetence or lack of interest in the men appointed to the work, from the short periods with

which they would be connected with it, and the fact that they had no personal interest at stake in it except their salaries.

His plan therefore proposed that, instead of the Government's attempting to conduct the experiment directly, public aid should be extended to a private corporation to be created as a research agency.

In "Man and Nature", published in 1864, Marsh had said:

> It is much to be feared that [public ownership and management] would be inadequate to save the forests of the American Union. There is little respect for public property in America, and the Federal Government, certainly, would not be the proper agent of the Nation for this purpose. It proved itself unable to protect the liveoak woods of Florida, which were intended to be preserved for the use of the Navy; and it more than once paid contractors a high price for timber stolen from its own forests. The authorities of the individual States might be more efficient.

If any evidence is needed of the debauched standard of political life in the era of the seventies, a single citation from the proceedings of Congress will provide it. A few weeks after the House of Representatives received the Colorado memorial one of its members, George F. Hoar of Massachusetts, stood before the Senate as one of the House managers of the impeachment trial of the Secretary of War. In addressing that body, then sitting as a court, he said:

> My own public life has been a very brief and insignificant one, extending little beyond the duration of a single term of senatorial office. But in that brief period I have seen five judges of a high court of the United States driven from office by threats of impeachment for corruption or maladministration. I have heard the taunt, from friendliest lips, that when the United States presented herself in the East to take part with the civilized world in generous competition in the arts of life, the only product of her institutions in which she surpassed all others beyond question was her corruption. * * * When the greatest railroad of the world, binding together the continent and uniting the two great seas which wash our shores, was finished, I have seen our national triumph and exultation turned to bitterness and shame by the unanimous reports of three committees of Congress—two of the House and one here—that every step of that mighty enterprise had been taken in fraud. I have heard in highest places the shameless doctrine avowed by men grown old in public office that the true way by which power should be gained in the Republic is to bribe the people with the offices created for their service, and the true end for which it should be used when gained is the promotion of personal ambition and the gratification of personal revenge.

The American Association for the Advancement of Science, in taking action to make known to Congress its recommendations that a Federal agency should be set up to promote practices of timber growing throughout the United States, did not contemplate an organization charged with duties of administration. The association acted after, and presumably was induced to act by, the presentation of a paper "On the Duty of Governments in the Preservation of Forests." Although this paper pointed out that the questions involved "are not limited to a particular State, but interest the Nation generally," the action proposed for the association was that it should bring the subject of protection of the forests, and their cultivation, regulation, and encouragement, "to the notice of our several State governments, and Congress with respect to the Territories." The committee of the association which drafted a memorial to Congress seems to have sought the creation of an independent commission of forestry headed by a commissioner with a function paralleling that of the Commissioner of Agriculture and the Commissioner of Fisheries. What was contemplated and shortly brought to pass, in other words, was the setting up of a central clearing house of information and bureau for conducting statistical and other inquiries and organizing research. The number of States which already had begun to move in the direction of State encouragement of forestry, the movement under way in other States looking to similar action, and the conception then generally held of the respective spheres of action of the Federal Government and the States doubtless worked together to inspire the belief that the actual organization of whatever administrative activities might be found necessary would and should be provided for under State legislation and through State organization.

The provision actually made by Congress for the new activity was at first most meager and for a quarter of a century too insignificant to permit of any great expansion. The clearing house and bureau of information was at first a purely one-man affair. Nevertheless, as time went on the work began to get on its feet, and by the close of its first decade had reached the point at which it was capable of real usefulness as a central agency for promoting the forestry movement throughout the country.

The bold advocacy by Secretary of the Interior Schurz of the inauguration by the Federal Government of forestry administration of the public-domain timberland had an instantaneous effect on the conservationists of that period. The proposal was forthwith adopted as a part of the forestry program for which the support of the country was being sought. Bills looking to the inauguration of Federal administration were introduced into Congress in increasing number and with increasing support from without Congress. On the other hand, the opposition of antagonistic Western interests created obstacles too great to be overcome down to 1891, when there crept through unnoticed, in the crowded closing hours of the session, a briefly worded amendment authorizing the President to establish forest reserves.

It is now time to turn back to the development of State forest administration.

THE FIRST STAGES OF FORESTRY ADMINISTRATION BY THE STATES

Down to the year 1885 no governmental agency had been set up in the United States to undertake duties of an administrative character with respect to forestry, and no State had inaugurated forestry work as a continuing activity. After nearly 20 years of widening agitation, which had borne fruit in legislation by nearly half the States and by the Federal Government, almost nothing of real importance had been accomplished. The forestry movement had got off on a false start. It had formulated and pursued ill-advised objectives, and it had selected impractical means to attain them. The only form of public action which it had been able to propose and get adopted with a view to meeting public needs for future timber supplies or providing the country with ample new forests was to pass laws extending inducement and encouragement for tree planting by private landowners; and while millions of trees had been planted, little of permanent value had resulted, from the standpoint of finding a practical answer to the country's forest problem.

This is not to say that tree planting in the naturally treeless prairie and plains region of the West failed to produce substantial results. Those who settled and built up the country felt the need of trees for shade, protection, and wood; and as their homes and villages multiplied the bare aspect of the prairie was broken and gradually transformed. Planted woodlots, shelterbelts, and shade trees marking the farmsteads and the villages now so plentifully dot the landscape of the eastern prairie region that it no longer appears to the passing traveler like a naturally treeless country, and seems not greatly different from the originally wooded East. Not only has the early desire of those who sought to promote tree planting throughout this region been largely realized; the planted timber growth is of appreciable economic importance as a source of wood supply for local requirements. But the afforestation movement in the West owes very little to the laws in aid of timber culture through bounties, tax exemptions, and land bestowal passed under the impulse of the early forestry movement. In fact, the laws soon proved valueless and unsatisfactory in their actual working, and most of them were eventually repealed.

In 1885, however, the forestry problem began to be attacked from a new angle. In that year four States—New York, Ohio, Colorado, and California—created forestry organizations charged with the conduct of specific functional activities on behalf of the States. This was the beginning of State forestry administration.

Only in New York did the initial forestry organization prove permanent. In Ohio a promising start lost headway after a few years, with the result that the work was discontinued in 1890. In California an originally energetic organization got into political hot water and, after an existence of 8 years, was abolished. In Colorado the new venture in State government had a still more ignominous history. Practically it was a still-born thing. Although for a few years it functioned to some extent as an agency to promote interest in forest preservation, the administrative responsibilities contemplated by the law could not be discharged, partly because the law itself was unworkable, partly because of lack of appropriations to sustain the organization theoretically created.

The failures in Colorado and California are instructive. They are the two Western States in which there existed at that time a definitely crystallized and fairly vigorous State movement for forestry. In both States the principal ground of interest was the value of water for irrigation and fear of the results of forest destruction in the mountains—though in both States also the question of permanent timber supplies and the terrific wastefulness and destructiveness with which the forests were being assailed entered in considerably. Further, in both States the crux of the difficulty in trying to formulate a program of public action to preserve the forests was the fact that they were principally a part of the public domain.

The difficulty thus created was not merely the lack of authority of the State over Federal holdings. It was the powerful antagonistic interests adverse to forestry which stood to benefit from Federal inattention, indifference, liberality of the laws relating to the disposal of public lands and the use of timber from them, and laxity in the administration of these liberal laws.

Both the strength of the conservationists in Colorado and the insuperable difficulties confronting them when they attempted to bring about the actual adoption and application of constructive measures are evidenced by the bare facts. That the deep solicitude on behalf of forest preservation expressed in the memorial to Congress adopted by the Colorado Constitutional Convention in 1876 was genuine seems unquestionable. The mandate of the State constitution requiring that the legislature should enact laws both "to prevent the destruction of, and to keep in good preservation, the forests upon the lands of the State, or upon lands of the public domain the control of which shall be conferred by Congress upon the State", was another expression of the same solicitude. But the enactment by Congress of laws working in the opposite direction was very actively aided by men elected to that body from Colorado; the laxity of the administration of the public land laws under Secretary of the Interior Teller—a Colorado man—between 1882 and 1885 was outstanding; and not until the latter year did the legislature of Colorado give heed to the constitutional mandate. The law then passed provided for the appointment of a forest commissioner to have care of the woodlands of the State, to protect them against trespass and fire, and to make and publish reasonable rules and regulations for their protection and for the conservation of forest growth; but this was principally a gesture. A prominent citizen of the State who was for years among the most active advocates and backers of forestry was appointed Forest Commissioner, serving at first with no salary at all, but was unable to accomplish anything of importance; and about 1891 the effort was halted through discontinuance of the appropriation. Thus came to an end the first effort to establish forest administration in Colorado.

Before leaving the subject it should be said that the law made county commissioners and road overseers forest officers who should guard against fire and depredation, with authority to arrest offenders; the expenditures in any county for protection of the forests were limited to $100 in any year.

California made a more impressive record. Its "State Board of Forestry" was the first agency designed to be of permanent character created by any State to have charge of its forestry interests. The board comprised three unsalaried members, with authority to appoint a salaried secretary and with an appropriation of $5,000 for the first biennium. With the second biennium the appropriation was increased to $29,500. The duties of the board were to collect and disseminate information, to conduct investigations and experiments, to encourage the preservation and planting of forests and the maintenance of water resources, and also to assist in enforcing and carrying out all National and State forestry laws.

The board proceeded with much energy and ability to develop a highly promising, comprehensive program, and to build up an organization. In 1887 its officers and employees were endowed with the powers of peace officers for making arrests when laws applying to forest or brush lands within the State were broken. A body of agents was created to aid in law enforcement and protection against forest fire.

In California, as in Colorado, the inertness of the Federal Government in protecting the public domain timberlands from spoliation and the great ravages of forest fires created sentiment for State ownership and administration of the public domain timberland. An expression of this sentiment took the form of a bill introduced into Congress and reported favorably by the Public Lands Committee, in 1887, to withdraw from sale public domain forest lands in California not suited to agriculture, and to place them temporarily under the management of the State Board of Forestry.

For the biennium 1891–92 the appropriation of the California State Board of Forestry was increased to $30,000. But the board was getting into difficulties. In September 1890 a significant resolution was adopted by the American Forestry Congress. It recited that the board was both—

> charged with the forestry interests of [the] State in general, and with the protection of the timberlands of said State against fire and depredation,

etc. But—

> it has been suggested that political considerations may lead to a discontinuance of said board, or to such a reduction of the appropriations provided for such board as must necessarily hamper its work and curtail its usefulness.

The Congress viewed

> with alarm the possible occurrence of such a contingency, rooting out, as it were, the first germ of a rational forest policy, which the State of California had wisely planted, and cannot without detriment to its agricultural interests afford to discontinue—

and accordingly provision was made

> that a copy of these expressions of interest in the forest policy of the State of California be forwarded to the governor and legislature of the State of California.

In 1893 the board was abolished, and a most promising effort to build up a State organization for the protection of the publicly owned timberlands (mainly Federal, of course) in California was brought to an end. There had been a collision with conflicting interests. The principal effort of the board in protection was directed at law enforcement. It sought to get the goods on timber thieves and fraudulent entrymen. The State itself had its school lands, which were being very rapidly acquired by private owners. The rush of eastern lumbermen to build up great private holdings in the West Coast States had set in. And there were the sheepmen. Said the report of the executive officer of the board in 1892:

> Sheep raising and timber cutting are legitimate pursuits and entitled to fair treatment, but as conducted in California for many years they have not been conducive to the general welfare. The millman has slashed the forests recklessly, wasting more than he used, and not confining his operations to his own property. The sheep herder, caring only for pasturage, has set fire to the brush annually, burning off the young growth and killing the large trees. The seedlings and shoots that escaped the forest fires were destroyed by the sheep. And so not only has the mature forest been greatly injured, but the total extinction of the forest growth made inevitable unless the work of devastation be stopped.

Arrayed on the other side, and deeply convinced of the necessity of forest preservation, were the agricultural interests of the State. "California has been awakened", said the same report—

> to at least a partial recognition of her danger by the necessity of organizing and perfecting a system of irrigation for the development of her arid plains. She has discovered that water will make gardens of her deserts, and that the key to future prosperity and greatness is irrigation. Now she turns to the Sierra Nevada as the storehouse of her wealth. The mountains that yielded the gold that made California rich in the early days contain the sources of greater and more enduring wealth. The water flowing in California rivers is more precious than the gold lying hidden in their sands. So long as the forests cover the mountain sides, the streams will flow with some evenness throughout the year; but when the forests disappear, the rivers will become rushing torrents in the spring and dry arroyos all the rest of the year. The forests of the Sierra Nevada are the natural reservoirs for irrigation of the San Joaquin Valley.

The opiate administered to the State forestry organization in 1893 remained potent for 12 years. Its Rip Van Winkle slumber ended with the act of March 18, 1905, creating anew a State board of forestry, and under it the office of State forester. The first report of the State forester contains this paragraph:

> From 1893 to 1903 forestry in California was at a standstill, yet this period was one of marked need and of rapid development along other lines. It was the decade during which the lumbermen from the Lake States and southern pineries flocked to California to invest in timberlands, and during which time California disposed of the bulk of her sole forest possessions by the sale of school lands at the ridiculously low price of $1.25 per acre. Similarly it was the period during which land fraud flourished, whereby much of the public timberland in California was lost to the National Government and the State.

The date of 1903 in the preceding paragraph calls for explanation. The national forestry movement had not been dormant during the previous decade. The feeble and ill-supported, though valiantly struggling, little bureau of information officially known as the Division of Forestry of the United States Department of Agriculture had been transformed into the strong, rapidly growing, nationally observed Bureau of Forestry, in the same Department. In 1903 the California Legislature made provision for the undertaking of a thorough investigation of the forest resources of the State by the Federal Bureau of Forestry, under a cooperative agreement by the terms of which the cost of the survey was borne equally by the Federal Government and the States. As a result of this investigation, measures were formulated and recommended to the State legislature in the form of a bill which led to the act of March 18, 1905.

For Ohio, the story of its short-lived first forestry bureau can be much more briefly told. It was a case of good seed dropped on too shallow soil. In the early eighties there were evidences of marked forestry interest in the State, with enthusiastic leadership. The legislature created in 1885 the Ohio State Forestry Bureau, as a central office for the promotion of forestry, with headquarters at the State university, and with a frugal appropriation of $1,000. It was charged with the duties of inquiring into the extent and character of the forest resources of Ohio and investigating the causes that are operating to destroy the forest; of suggesting legislation; and, permissively, of establishing a forest station on the university grounds, with the consent of the university trustees. Six successive annual reports testify to the activity and diligence with which the secretary—said to have studied forestry in Europe—endeavored to gather and diffuse information. Presumably waning interest due to the dropping off of the leaders in the State forestry movement was the cause of the extinction of the bureau in 1890.

And, finally, New York.

The State forest policy of New York has been throughout *sui generis*. In less degree than in any other State has it been subject to external influences. Throughout it has been a policy developed by the State to meet its own conditions and in response to its own felt needs. And to a greater degree than in any other State it has centered in and been mainly preoccupied with State forest-land administration.

As early as 1868 public advocacy of a policy of reservation for lands of the State in the Adirondacks began. Sale of these wilderness lands had been going on from the latter part of the eighteenth century, at low prices. The lands were bought for the sake of their standing timber where and when lumbermen saw a chance for a profitable operation. But after as much of the timber as was valuable at the time had been cut off, the lands were often allowed to revert to the State through nonpayment of taxes. When through added growth or advancing lumber prices they become valuable again, they were rebought to repeat the process. In his annual message of January 1, 1884, Governor Grover Cleveland pointed out how, under the established procedure for dealing with tax-delinquent lands, owners who from the first day of their ownership had refused payment of all taxes had from 7 to 12 years in which to cut off and sell the timber before the State foreclosed on the land. Twelve years before this message the legislature had appointed a temporary commission of inquiry; but its recommendations had languished until 1883. In that year the legislature put a stop to the revolving system of alternate public and private ownership; and in 1884 it authorized the comptroller to employ "such experts as he may deem necessary to investigate and report a system of forest preservation." The commission was headed by Prof. Charles S. Sargent, of Harvard, and made its report the following year. Opposition said to have come partly from lumbering interests resulted in the passage of a compromise act, the law of 1885, establishing a permanent forest commission to "have the care, custody, control, and superintendence of the forest preserve", and generally to promote forestry throughout the State by means of various specified activities.

The law of 1885 also put into effect a system of organized fire protection for both public and private forest lands within the State, the provisions of which will be discussed later.

The task imposed upon the Commission at the outset with respect to the State lands was of Herculean proportions. From time out of mind these lands had been subject to depredations, often highly lucrative to those engaged in them, and similar in many ways to those to which the Federal public domain was exposed. It is improbable that the members of the Commission, at the time of their appointment, were under any illusions regarding the unpopularity with which any whole-hearted attempt to enforce the laws against stealing timber from the State lands would be received, and the hornet's nest that honest performance of their duties was bound to stir up; but if they were, their minds must have been very promptly disabused, Local custom confirmed by State complaisance had given the lands virtually the status of public commons, in the eyes at least of those who lived in their general neighborhood; and the business interests which stood to lose by a sudden drying up of the supply of bootlegged logs were certain to be heard from by the Governor's appointees. That their course had aroused both resentment and opposition the words of their second annual report bore testimony to, in a passage which said:

> The Commissioners, of course, could not have remained in ignorance of the fact that in the performance of the official duties with which they were charged they have incurred the suppressed ill-will in some cases, and in others the open hostility of those with whom they have been compelled to deal. * * * They are conscious that they have intentionally given offense or caused injury to no man, and that in all instances they have pursued their work with none but the kindliest feelings, exercising at the same time as much leniency and forbearance as was compatible with the ends of justice. While, on the one hand, they have shown no favoritism, so, on the other, they have shown no hostility and felt

none. * * * On the other hand, they cannot but feel gratified at the high commendation which has been passed generally upon the course that they have pursued and at the great interest that is everywhere felt in the work in which they are engaged.

Of the varied kinds of "bold and knavish attempts to plunder the State" which "the Commission is attempting to stop" a single illustrative example may be cited.

It has been shown by figures that during the years 1871 to 1876 one individual cut from State land 52,131.91 market logs, valued at the lowest estimate at more than $52,000. He was only one of many who were engaged in this work of plunder during the same period, and was by no means the largest operator. What is true of the years before specified, is true of the succeeding years, and of how many preceding years is and must remain unknown.

The Commissioners had their difficulties, too, in finding the right men for the various local positions which they had to fill. The Federal Government had, through the enactment of the civil service law of 1883, taken a small first step toward the introduction of the merit system, as a means of obtaining competent civil servants and preventing the influence of politicians from getting or forcing on the public pay roll incompetent or otherwise unfit men; but "snivel-service reform" was anathema to all practical politicians and had many ups and downs to go through before State authorities were even to begin to take it seriously. Since—

the Commissioners could not possibly have such an extensive acquaintance throughout the 14 counties of the forest preserve as to enable them to select men from a personal knowledge of their qualification,

they had to—

rely largely upon the recommendations of known and trusted men throughout the different localities from which the foresters were to be chosen. To say that under these circumstances some mistakes in making selections were possible is simply to utter a truism. * * * Many applicants were pressed upon the Commission for appointment, with the best intentions doubtless, whom the Commissioners felt compelled to reject as being, in their opinion, unfit for the services required of them.

Multitudinous other difficulties incidental to defining the objectives, laying out the plans, and building up the organization for a public enterprise wholly new and undefined in character, with no precedent to guide and very little information to enlighten them, had also to be dealt with.

The science of forestry in America is yet in its swaddling clothes—it is, perhaps, a risk to assume that its toilet is so far made as that. Even the practical business matters that have been presented to the Commission for investigation and settlement * * * involved substantially new questions, demanded much investigation, were beclouded with much loosely woven legislation, and were often entangled in such contradictory enactments, opinions, discussions, and rulings as to render it difficult to find a clue out of the labyrinth.[1]

Moreover, it was difficult to establish the location and extent of the land owned by the State.

The forest preserve is made up of many disconnected plots, more in some counties than in others; plots, ranging from a few acres up to many thousands, surrounded usually by lands owned by individuals and in many cases inaccessible by roads. * * * There are large tracts in which the State owns but an undivided interest, one half, one third, or one fourth, as the case may be, and instances are on record where individuals thus owning with the State have not waited for a partition, but have gone on and lumbered the whole.[2]

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[1] Annual Report of the Forest Commission of the State of New York for 1886, p. 7.

[2] Annual Report of the Forest Commission of the State of New York for 1885, p. 17.

The second annual report of the Commission quoted from one of its inspectors:

> The State in past years has expended large sums of money with the view of correctly locating its lands according to the original surveys and of furnishing a correct map, drawn to such a scale that individual plots are plainly shown. That this has never been accomplished those best know who have had occasion to investigate the matter. * * * Many examinations of State lots have been made during the past season, but in every case it required an expert to locate the corners or lines.

Experts were either old residents who themselves had worked out the lines or persons familiar with the local condition, "handed down with other matters of local importance", regarding property boundaries. Most of the surveys establishing the lines and corners had been made in the latter part of the eighteenth and the early part of the nineteenth century. Trees were marked for corners, with the true corner marked by a stake ("the perished monument of an hundred years ago"), supplemented by a corner marking on some tree near at hand. In marking the lines between the corners, trees were blazed both on the true line and on trees each side of the line. Through the death and fall of many of the marked trees, the accurate reestablishment of the original line, in many places almost entirely and sometimes purposely obliterated, became a very difficult task.

THE NEW YORK PROBLEM OF OBJECTIVES

The major problems with which the commission had to grapple during its first several years, other than those relating to building up a suitable form of organization, were problems having to do with land acquisition and land retention, and the protection of the State land and timber against spoliation and fire. That the State lands badly needed blocking up has already been shown. At the time that the policy of State retention of tax forfeited lands was inaugurated, it was assumed that further tax forfeitures would continue to operate as a means of extending and consolidating the State properties. In point of fact, the adoption of the State policy came just at the time when the tide turned. The Adirondack region was about to enter a period of rising land and timber values. As a recreation region, it was to change from an undeveloped wilderness paradise for hardy sportsmen into a resort country of hotels, cottages, private estates of wealthy men, extensive private club hunting grounds, and all that goes with popularity as a summer playground and fashionable watering place. Instead of getting more land through tax reversions, the commissioners found themselves losing a good deal of the land already obtained. Laws passed in the days when the main anxiety of the State was to get rid of its land made it possible for many claimants to attack the State's title, on the flimsiest kind of evidence.

> There can be little doubt—

Said the commission in its report for 1888—

> that many applications for both cancellations and redemptions of the State's title have been based upon fraudulent affidavits and misrepresentation of facts, and that many such fraudulent applications have been successful.

Defense of the State's property against the pillage of its timber raised other difficult legal problems. Until the commission had its hands less full in trying to hold the property of the State against adverse claimants and prevent its spoliation, it could not do much to develop constructive plans for its future use.

One thing, however, was obvious—that some way to block up the scattered and broken holdings of the State must be found, if they were to be effectively administered. A small first step in this direction was taken in 1887, by amendment of the provision of the 1885 law under which none of the land of the forest preserve could be sold. The amendment permitted sale to the highest bidder "of separate small parcels or tracts wholly detached from the main portions of the forest preserve and bounded on every side by lands not owned by the State", the proceeds to be invested in the purchase of forest land "adjoining great blocks of the forest preserve now owned by the State"; or the isolated small tracts might be exchanged for land adjoining the main holdings. The following year (1888) the commission asked the legislature to make an appropriation annually for land purchases, at a price not to exceed $1.50 per acre. This opened up in earnest the question, What were to be the objectives of State administration?

That the most important purpose was to conserve and regulate the water supply was universally accepted. That the forests of the Adirondack Plateau exercised other beneficial influences which made their preservation essential for the general welfare was also fully accepted. That their recreational and health values were further reasons for preserving them also went without dispute. Beyond these ends the law of 1885 had not definitely looked. In essence, that law had simply said that the State should dispose of no more forest land, and that the destruction of the forests on the State lands should be stopped. This, the Forest Commission said in its 1888 report, "has been termed 'forestry', but that is a too wide and sometimes a misleading term." The "forest preservation" contemplated by the act—

> could then have implied little more than an attempt to secure the forests from the ax of the lumberman, and from the torch of the careless or willful incendiary.

In this, however, the legislature had drawn back from the course recommended by the Forestry Commission of 1884. For that commission had had in view also the perpetuation of the industries dependent upon the forests for wood, and the permanent production of forest products through the practice of forestry.

"The Adirondack region", the report of the 1884 commission had said—

> if the experience of other countries in forest management teaches anything, could be made to maintain and increase, under a wise and comprehensive policy, the annual output of lumber without serious injury to the forests as reservoirs of moisture or as health resorts for the people; and it is clearly in the interest of the owners of forest property as well as for the people of this State to encourage the adoption of any system of management which will insure such results.

Accordingly, their recommended bill included express provision for the disposal by the commission "of such timber, standing or cut, as shall have grown to an age which renders it advantageous for the general preservation of the forests that the said timber should be removed" in accordance with such conditions as the commission might fix.

It is true that the law of 1885 afforded some basis for construing it as designed to permit, or at least as not entirely prohibiting, forest management. While the lands of the forest preserve must "be forever kept as wild lands", the commission was—

> to maintain and protect the forests now on the forest preserve, and to promote as far as practicable the further growth of forests thereon;

the commission was authorized to prescribe rules or regulations for the use, care, and administration of the preserve; and a subsequent section directed the commission to pay over to the treasury of the State "all income that may hereafter be derived from State forest lands." However, the commission plainly felt that before it could undertake to sell any timber from the preserve it must have further legislative authorization. In its 1892 report a draft of recommended legislation was incorporated authorizing the sale of spruce and tamarack having a diameter of 12 inches or more, and of poplar without a diameter restriction. Two years earlier the commission had suggested the possibility of acquiring land for purposes of blocking up through exchanges of timber for land, with the cutting limited to the softwoods and the same 12-inch diameter limitation. That this suggestion would meet with opposition, however, was evidently realized.

> Your commission is fully appraised of the prejudice that exists in many quarters against selling trees of any sort, and under any circumstances, in the Adirondack forest.

The report of the commission continued—

> Considering the manner in which trees have been heretofore cut, and the devastation that has been wrought by crude and thoughtless methods, this prejudice is not surprising; nevertheless it is a prejudice. * * * No scheme of forestry is complete that does not contemplate the preservation and cultivation of timber for the sake of wood to be used for merchantable purposes * * *. Forestry is not opposed to having trees cut down in the proper way. They must be cut to supply the world with timber. * * * It is the unwise, improvident, stupid method, or want of method, by which the cutting has heretofore too often been done, that is deplored.

And so on.

The "prejudice" which it was thus sought to dissipate was not confined to New York. It was to find expression not much later in Congress, during the discussion of proposed legislation to permit sales of timber from the Federal forest reserves. In 1891 Congress authorized the President to establish forest reserves; but not until 8 years later was any provision made for their administration. In the interval the friends of forest conservation directed their principal efforts toward getting the necessary legislation through. Inasmuch as water conservation held overwhelmingly the first place, in the eyes of the West, as a reason for having forest reserves, to open them to lumbering seemed to many not merely dangerous but a complete abandonment of the reserve policy. As one Congressman put it—

> You might as well turn a dozen wolves into a corral filled with sheep and expect the wolves to protect the sheep as to expect your timber to be protected if you permit the lumbermen to go upon the reservation at all.

While unfamiliarity with the practices of forestry doubtless in part explained this attitude and fear, it is far from being the whole explanation. In very large part the basis of the fear was the distrust, based on long experience, of the ability of any body of public servants to maintain against pressure and corrupting influences a high standard of competence, vigilance, and integrity. Indeed, a good many of the forest conservationists, who were trying to get Congress to allow the practice of forestry on the Federal forest reserves, had the same qualms. They were much inclined to have the job of administration turned over to the Army, on the ground that only so could a professional spirit and a reasonable expectation of honesty be assured. That the citizens of New York should feel less distruct concerning what might happen if their own civil servants should be entrusted with the business of selling the State's timber, or any part of it, was hardly to be expected.

NEW YORK'S DECISION FOR THE ADIRONDACKS

But besides these negative reasons against opening the Adirondack forest to timber cutting, there was a powerful positive one. The State was making up its own mind on what it wanted done and not done. Early in the year 1890 the Governor of New York had placed before the legislature the need for consolidating the State's scattered holdings and had suggested that steps be taken to work out a plan for a compact State park in the Adirondacks, from 50 to 70 miles square. Thereupon the legislature directed the Forest Commission to take the whole matter under consideration and make a report on it. Public opinion rallied strongly behind the proposal. It soon became evident that what the people of the State of New York chiefly wanted was to have the Adirondack wilderness, with its mountains, lakes, and woods, kept and maintained as a great recreation area, and that the public was inclined to regard timber utilization of any kind as conflicting with this purpose.

Governor Flower's term of office brought a showdown. He advocated a policy designed to obtain from the State's holdings a substantial revenue through sales of timber and through leasing sites desirable for private residences and camps. The legislature, in carrying out his recommendations, wiped out of existence the old Forest Commission, set up a new commission of temporary character with provision that after 5 years its powers and duties should pass to the State department of agriculture, established the Adirondack Park, authorized the sale of lands outside the park with use of the proceeds for the purchase of lands within the park, and permitted the Forest Commissioners to—

> sell any spruce and tamarack timber which is not less than 12 inches in diameter at a height of 3 feet above the ground, standing in any part of the forest preserve, and poplar timber of such size as the Forest Commission may determine

and to lease within the Adirondack Park tracts of 5 acres or less for the erection of camps or cottages; these proceeds also to go into the land purchase fund.

Governor Flower thought that in time the State should be able to derive a large portion of its revenues from its forest properties. But he had greatly mistaken the public temper. The criticism and protest took organized form, and upon the convening, in 1894, of a convention to revise the State constitution it brought about the incorporation in that instrument of an absolute prohibition of any cutting of timber from the State lands, or of any leasing of these lands.

The plans for selling timber from the New York Forest Preserve drew sharp fire not only from those who were against utilizing the timber in accordance with the methods of forestry but also from those who wished it done. For, as foresters were quick to point out, the plans for utilizing the timber ran quite contrary to sound principles of forestry practice. The Forest Commission made the mistake of trying to devise and put into effect plans for timber growing and harvesting without technical experience or outside advice. The State had not succeeded in creating an organization meriting public confidence either in its competence to apply practices of forestry wisely or in its ability to maintain high standards of integrity. Immediately after the constitutional amendment was adopted Garden and Forest (a publication conducted by Prof. Charles S. Sargent) said in comment:

> No doubt the adoption of this amendment was made easier by the revelation of corruption in the administration of the forest lands which had been made during the week by the comptroller of the State. These revelations show that there has been fraud and bribery in the transfer of lands and much cutting of timber in the State forests which was not only illegal but the result of conspiracy between trespassers and public officers. The adoption of this amendment certainly demonstrates an increased interest in the subject of forestry, and it may relieve the forests from some danger. Nevertheless, we consider it a misfortune that such a provision should be imbedded as a principle in the fundamental law of the State. It assumes (1) that there is no such thing as rational and conservative forestry, or (2) that a civilized American community cannot be trusted to organize and develop any such a system of forest practice, either because our people lack the intelligence to do this in a scientific way, or because they lack the moral fiber to administer such a trust without official knavery and peculation.

FURTHER DEVELOPMENT OF FOREST ADMINISTRATION IN NEW YORK, TO 1915

But the people of the State of New York had still to learn that a legislative decree, even when clothed with supreme authority through its embodiment in a constitutional amendment, is not self-enforcing. That public sentiment throughout the State was whole-heartedly in favor of saving the Adirondack Forest and building up a great consolidated State park for public use is unquestionable. Practically the entire press of the State backed the policy. It was not the absence of public interest, but the presence of private interest, that made the outcome uncertain.

Public property of any kind that is worth getting hold of inevitably invites predatory attack, as honey draws bees. Because the people of New York felt that they could not safely leave the destinies of the State park within the power of the legislature to determine and modify, they set up the powerful safeguard of the constitutional amendment. To bring about its passage by the Constitutional Convention of 1894, and subsequently to watch over its observance, influential organizations had entered the field. Among these was the Association for the Protection of the Adirondacks. The fifth annual report of this association, covering the year 1905, set forth the results of an investigation initiated by the governor in view of certain findings which the association had laid before him. The report said:

> As the official investigation progressed, the facts already gathered by the association's assistant secretary in his personal visit to the woods were more than confirmed. It was found that between 15 million and 16 million board feet of timber had been removed unlawfully from State land during the preceding year with the knowledge of the authorities whose duty it was to prevent it, and that it was done under a well-understood system of friendly cooperation by which the trespassers were permitted to go through a form of confessing judgment and

> paying for the timber at a rate so low as to make the transaction profitable to the trespassers. Not only was the mandatory legal penalty of $10 per tree not exacted but the so-called confessions of judgment for the larger trespasses were made before justices of the peace in a manner not allowed by law, and the timber was removed from State land in direct contravention of the constitution and the opinion of the attorney general given to the Forest, Fish, and Game Commissioner.

It is unnecessary for the present purpose to follow much further in detail the gradual evolution in New York of forest land administration as a successful State activity. There were still many vicissitudes to be gone through before the administrative organization emerged as an agency of State government accorded, and deserving of, the full support and confidence of the people. Progress was made more difficult for a time by the fusion which combined into one department the forest commission and the fish and game commission. Until within relatively recent years State fish and game departments have practically everywhere, by common acceptance, been integrated with the State political machines. Efficient management of great public forest properties calls for their specialized administration by men of suitable technical training and professional spirit and background. The discharge with competence, impartiality, and sole allegiance to the public welfare of functions of trusteeship is involved. To assure a proper continuity and stability of management, as well as to have throughout the organization good discipline and diligence, the selection, promotion, and retention of men must be governed by their ability and performance within the organization, not by outside considerations or influence. Political machines and business machines do not admit of successful combination. They should run separately. The story of State forest administration in New York during the 20-year period which began with the adoption of the constitutional amendment was epitomized by the author of A History of the Adirondacks, Alfred L. Donaldson, in the following terms:

> These were lean years for the forests. They were years of almost unceasing, though unsuccessful, attacks upon the new amendment. They were years of much lax administration, resulting in enormous lumber thefts and much questionable surrendering of the State's title to its lands; they were, worst of all, years of the most extensive and destructive forest fires. The lesson of all these losses was driven home, however, and the dawn of new era began.

The same author painted this dawning in a passage which, somewhat abbreviated, records the narrative thus:

> The sensation of the year [1914] in forest circles was sprung in December, when Governor Glynn appointed Patrick McCabe, of Albany, * * * as one of the three conservation commissioners. * * * Men high up in the councils of the Democratic Party protested against the appointment, but in vain. * * * The New York World said in part:
>
> "McCabe is the boss of Albany. He has been one of Murphy's stanchest supporters since the latter assumed the leadership of Tammany Hall. * * * He is the most practical of practical politicians, a spoilsman and reactionary of the most pronounced type, ready to stand for anything and everything that Murphy decrees."
>
> This indefensible appointment became a direct influence in bringing about changes in the conservation law that legislated Mr. McCabe out of office the following year.
>
> * * * * * * *
>
> In his inaugural message [of January 1915] Governor Whitman urged certain changes in the conservation law, the most important of which were summed up as follows:
>
> First. A single-headed commission.

Second. A strict requirement in the law that the administrative head of each department should be a trained expert.

Third. A strict requirement in the law that all of the important subordinates shall be trained experts, appointed in accordance with the provisions of the civil service law.

The resulting law, passed April 16 of the same year, provided for a single conservation commissioner to be appointed by the governor for a period of 6 years, at a salary of $8,000 a year. The commissioner had power to appoint a deputy commissioner, also a superintendent of forests, who would become chief of the division of lands and forests; a chief game protector, who would become chief of the division of fish and game; a division engineer, who would become chief of the division of waters, and various other subordinates.

THE ORIGIN OF THE "CONSERVATION DEPARTMENT" IDEA

New York was not the first State to place its forestry work in a "conservation department", nor did the law of 1915 provide the first set-up in New York of a department designated by this title—the conservation law of 1911 had combined the forest, fish, and game commission, forest purchasing board, State water supply commission, and the commissioner of water power on the Black River into a new department, headed by a State conservation commission of three members. During President Roosevelt's administration the conservation movement had swept the country, and one of its consequences was a strong trend toward bringing together various more or less related State activities in conservation departments of various types. Two distinct and somewhat conflicting conceptions of the field and objectives of conservation manifested themselves in the form of set-up, and largely explained the divergence in their types.

The Roosevelt conservation movement had had to do with, primarily, the great basic natural resources of the country. Its concern was for the main foundations underlying and supporting the economic life and material welfare of the Nation. To the end that the Nation might long endure as a great power in the family of nations and as a happy and prosperous people, the conservation movement sought to assure the perpetuation, through wise and farsighted use, of the natural resources capable of perpetuation, and the husbanding through wise use of the wasting resources. In the White House conference of 1908 and the work of the Roosevelt Conservation Commission which grew out of it, a classification of natural resources was made under the four heads of minerals, lands, waters, and forests. Some of the State conservation departments tended to follow along the line suggested by this general conception.

In a way this was a revival of a trend which had appeared in some States in the very earliest stages of the forestry movement. It was exemplified in North Carolina, New Jersey, and several other States in which the Geological Survey was made the agency of the State to undertake the gathering of information on the forest resources. Departments of "conservation and development" expressed this idea. But in the popular mind conservation rapidly drifted away from the basic conception of the Roosevelt movement and associated itself with such things as the protection of wild life, landscape, scenic and natural wonders, and outdoor recreational opportunities; not rational and farsighted development of the best economic potentialities of material resources, but holding the despoiler in check and turning aside the march of civilization in the interest of the nature lover and of nature herself, or in the interest of sport and enjoyment of life in the open. A form of organization based on the idea that this is what conservation means has sometimes had an unfortunate effect upon forestry work, by placing it in association with activities of a different purpose and in charge of men whose background, interests, and training do not well fit them to understand the problems of forestry.

THE DEVELOPMENT OF STATE FORESTS IN PENNSYLVANIA

In Pennsylvania, as in New York, a policy of State acquisition and administration of forest land has from the outset held the most important place in its forest activities. Through the persistent missionary work on behalf of forestry which Dr. J. T. Rothrock had for many years been doing all over the State, an excellent groundwork of intelligent public interest had been laid before the forest policy was inaugurated. Heartily supported by each successive Governor, Dr. Rothrock as the first Commissioner of Forestry was able to bring about rapid progress in the building up of a system of State forests, the extension of which is still going on. The acquisition policy was entered upon in 1897, through authorization of the purchase by a commission of wild lands desirable for reservation by the State, if they could be had without bidding above the amount of taxes due. Somewhat less than 2 years thereafter the State had acquired not quite 20,000 acres. Four years later the amount exceeded 500,000 acres. Including lands in process of acquisition, it is now more than 1,600,000 acres.

From the outset the management of these lands under forestry principles for timber production was one of the primary objectives. Although the law has never required that the chief of the department be a trained forester, and although not until 1920 was the incumbent actually a trained forester, the department has had remarkable stability and continuity of policy. The incumbencies of Dr. Rothrock and his immediate successor, Robert F. Conklin, who had been with the department from the inauguration of its work, covered together a period of 25 years.

Nevertheless, it would be unsafe to say that the Pennsylvania Forestry Department (now the Pennsylvania Forest Service of the Department of Forests and Waters) has been wholly divorced from political influences, or that its stability can be regarded as too well established to make the danger of an overthrow or disintegration of the enterprise wholly negligible. There is only one State in the entire country in which the head of the forestry work is given by law the protection of a civil service standing, and only six in which the lower officers are given this protection. Pennsylvania provides neither. The successful management of valuable public resources requires competent direction, continuity, loyalty, and all the other requirements for the successful conduct of a private business. Until the States which have considerable forest properties recognize this and set up adequate safeguards against political pressure upon or use of the organization engaged in managing the properties, the forestry enterprises are exposed to unfortunate and unnecessary risks.

While in New York the chief impelling motive that gave shape to its forest policy was the desire to save the Adirondack region from despoliation and private appropriation in order to keep it as a great public recreation area, in Pennsylvania the chief motive was to restore to productivity a large aggregate area which had been so laid waste by destructive lumbering and fire that it came to be spoken of as the Pennsylvania desert. As a rule the lands were obtained at low prices during the early years, even when they were not acquired through tax sales, because they were regarded as practically worthless. To bring back a valuable forest growth in a reasonable time forest management under sound silvicultural practices was essential. In 1903 the State Forest Academy was established at Mont Alto to train youths of the State for its forest service. It was made the Pennsylvania State Forest School in 1923. Most of the administrative force are graduates of this school. Thus a competent body of technically trained forest officers has been provided. The State derived a gross income from the forests in 1931 of $42,268, of which $4,933 came from the sale of forest products, harvested under sound methods of utilization. In addition 9,000 cords of wood were taken from the forests under free-use permits. Rentals and leases, mainly of sites for summer homes and private camps, furnished the chief source of revenue, bringing in $27,677. Given security against the undermining effect on morale and the menace of instability and lowered standards created by the possibility that the organization may be utilized for political ends, the Pennsylvania Forest Service can be confidently expected to make the State forests steadily more valuable and of greater usefulness. Of all the States, Pennsylvania has achieved most in putting into effect actual forest management and reclaiming to economic productiveness through State acquisition and administration extensive areas of depleted and degenerated forest and idle cut-over land.

Yet after 35 years of continuous upbuilding of the State's forest policy, aided by a remarkably strong public approval and by steady support from virtually all the governors during the period, and although in per capita wealth and consequent capacity to engage in public undertakings for the general welfare the State ranks high, its program is far from its goal. An adequate meeting of its forest problem has not yet been provided for. How much longer it will take for the State to add to its present holdings the additional acreage which should be acquired and put under public management will doubtless depend largely on the exigencies and accidents that in the main govern the rate of progress in such matters.

THE FIRST STEPS IN ORGANIZED FIRE PROTECTION

The first step toward State systems of forest protection against fire was taken in 1885. Laws to curb fires by establishing civil liabilities and imposing penalties for malicious, willful, or negligent causing of fires had begun in early colonial days, and had continued progressively. In the main, the basic purpose of these laws was the protection of property values, public or private, against destruction or damage, by giving the owner right of redress through legal action or by prescribing punishment for incendiaries and those failing to use due care. To some extent, however, even these laws expressed recognition of a public interest involved, beyond the mere protection of property rights and prevention of property loss—the thought that forests were affected with a public interest. It was also seen that, merely from the standpoint of safeguarding property, something more was needed than laws to restrain from injurious acts or to fix responsibility for damages. Collective action to extinguish dangerous fires required to be provided for, supplementary to what the individual property owner or the individual citizen might choose or be able to do of his own initiative. From this need sprang the beginnings of the fire warden system.

It reaches back into the period when the functions of government relating to the daily activities and community interests of the citizenry were highly localized. Town and county officers, close to the people by whom they were chosen to run the public business, performed most of the executive and administrative duties which it fell to government to take care of. It was quite in accord with the spirit and method of the time that, when a public need was discovered for some organized provision for fire control, State legislation assigned this new duty to specified local officers and clothed them with the necessary authority. Thus, in 1788, New York imposed upon justices of the peace, town supervisors, highway commissioners, and militia officers the duty of extinguishing forest fires, with power to summon residents to assist under penalty of fine for failure to respond. Under the colonial laws of New York anyone discovering fire might summon assistance and anyone who failed or delayed to help was subject to a fine. Another New York colonial law provided for the election of firemen, similarly empowered, in certain towns.

An opening was cleared for a great advance when the Colorado and New York laws of 1885 introduced the principle of a centralized direction and supervision of the local warden force. In Colorado, and in New York outside the counties in which lay the State lands, the authority of the forestry commission was too shadowy under the 1885 laws to have any material effect. The most that the commission could do was to make suggestions, endeavor to arouse interest and an increased sense of responsibility, and ask for reports. If local officers chose to ignore the commission (and many did), the matter ended right there. The Colorado law merely said that the district and county forest officers "shall be subordinate to the Forest Commissioner of the State". That this law was very nearly a dead letter from the outset has already been said. The New York law occupied a much more important place in the history of forest-fire legislation and administration—so important a place, indeed, that it calls for consideration in some detail.

Dr. Bernhard E. Fernow, Chief of the Division of Forestry in the United States Department of Agriculture, 1886–98, claimed authorship of the New York forest-fire law. At the time of its enactment Dr. Fernow was secretary of the American Forestry Association. Writing in 1898, he said:

> The States of Maine, New Hampshire, Pennsylvania, Wisconsin, and Minnesota followed, with some modifications, this example of New York.

Directly under the Commission was a chief fire warden. Territorially, three forms of organization were set up. In counties which contained no wild or forest lands belonging to the State, the town supervisors were ex officio fire wardens, with authority to divide their towns into districts and appoint district wardens and with the duty of taking whatever measures might be necessary to extinguish fire. But with respect to the Commission the only relationship imposed upon them by law was a yearly report on all fires covering more than 1 acre, showing the size, damage, cause if ascertainable, and measures employed and found most effectual in stopping the fire. Supervisors of towns in which were wild or forest lands of the State not included within the 14 forest preserve counties were to be the protectors of these lands, subject to instructions of the Commission; and when so ordered by the Commission they were required to appoint one or more forest guards, whose powers, duties, and pay were to be determined by the Commission. On the other hand, in the 14 forest preserve counties the fire wardens were to be appointed specifically as such, by the Commission itself, and were to serve during the pleasure of the Commission.

As an efficient agency for holding fires in check, a local warden system without centralized authority of supervision and control compares with an up-to-date, trained, disciplined, and properly equipped protective organization very much as a sheriff's posse would compare with a Regular Army detachment for resisting a military raid. Fire control has become in the United States during the last 30 years a specialized branch of forestry in which, perhaps, greater progress has been made from the standpoint of developing the best technique than in any other branch. The fatal weakness, of course, in the initial form of State organization for fire control was its extreme decentralization, with its certainty of inefficiency, changing personnel, varying degree of interest and capacity, and entire lack of cohesion and discipline. And, of necessity, the town and county officers upon whom these laws imposed, irrespective of their fitness or interest, the duty of serving as fire wardens were either themselves local politicians or indebted to local politicians for their offices. So poorly was the first form of State protective organization contrived.

A great advance was made when, after a number of years, the principle began to be established that the head of the State forestry department must be a trained forester with adequate professional qualifications, freedom from political control, and full power to select and dismiss the local wardens. A half-way step toward this centralization of authority was the provision made in the fire laws of a number of States whereby local wardens were appointed by town or county officers, subject to the approval of the State Forester with power vested in the latter to remove or obtain the removal of unsatisfactory men. But the development of really efficient State systems of forest protection did not take place until the Federal Government had worked out, on the national forests, practices and methods which the States could take over and adapt to their needs; and the period of real progress in the development of efficient State administration of fire protection was ushered in by the enactment of the Weeks law, in 1911, providing for Federal cooperation and financial aid to the States.

SUMMARY OF PROGRESS IN STATE FORESTRY ACTIVITIES DOWN TO PASSAGE OF THE WEEKS LAW

The progress made by the States between 1885 and the beginning of 1911 in organizing their forestry activities is partly indicated by the legislation of the period, which is summarized below. The summary is not complete, and in some details is probably inaccurate, since full information on the subject has never been brought together; but it serves to give a birdseye view of the general movement. After 1890, laws designed to encourage timber growing through bounties or special taxation provisions are not included, since the subject of forest taxation is somewhat apart from the present matter of concern—namely, the development of State forestry activities as an organized governmental administrative function.

1885. California State Board of Forestry created; to gather and diffuse information, conduct experiments in tree planting, and aid in enforcing all forestry laws.

Dakota Territory offered a bounty for the planting and cultivating of forest trees.

New York State Forest Commission created; to administer the forest preserve, administer and supervise fire protection, and promote forest preservation and extension throughout the State.

Nebraska provided by law for the observance of Arbor Day.

Colorado created office of forest commissioner to have the care of the State's woodlands and promote forestry; county commissioners and district road overseers made forest officers subordinate to the forest commissioner in matters pertaining to woodlands; counties might expend their own funds locally up to $100.

Ohio State Forestry Bureau created, with investigative, advisory, and educational duties.

1886. Utah Territory provided an exemption from taxation for lands planted to forest trees for timber purposes.

1887. Kansas created office of commissioner of forestry; to set up two forest experiment stations and promote interest in forestry.

Pennsylvania created a temporary commission of inquiry.

1889. New Hampshire created a temporary commission to inquire into the feasibility of State purchases of mountain timberlands.

1890. Wyoming offered a bounty for the planting and cultivating of forest trees.

North Dakota law to encourage forest planting through tax exemption.

South Dakota law to encourage forest planting through bounty.

1891. North Dakota created office of State superintendent of irrigation and forestry, to diffuse information and promote tree culture.

North Carolina law required State geological survey to undertake study of timber resources.

Maine State land commissioner made ex-officio forest commissioner; charged with certain educational and informational duties, but principally with administration of forest-fire protection under warden system; selectmen to act as wardens in organized towns, with appointive special wardens for unorganized towns.

1893. New Hampshire created permanent unsalaried forestry commission with paid secretary, mainly as an agency of inquiry and education but with authority to purchase lands for park purposes with any donated funds. Selectmen made fire wardens.

Pennsylvania created a second commission of inquiry, of two salaried members.

1894. New Jersey required State geologist to gather information on forest lands owned by the State and the desirability of holding them, and on watershed conditions, forest influences, and the forest laws of other States.

Minnesota required investigation of State's forest resources by its geological survey.

1895. Wisconsin made chief clerk of State land office State fire warden ex-officio, and town supervisors and road superintendents town wardens under supervision of the State warden, with authority to the latter to make and publish regulations for protection of the forests of the State. Costs of fighting fires to be borne by the towns, with $100 limit.

Minnesota made State auditor forest commissioner with authority to appoint a chief fire warden. Duties included fire prevention and suppression, and forestry investigation and education. Town supervisors wardens ex-officio; other wardens might be appointed where needed. Wardens empowered to call out residents for fire fighting.

1895. Pennsylvania created a State department of agriculture with a commissioner of forestry included in it. Duties of department included the promotion of forestry, through gathering and publishing forestry information and giving practical advice; the making and carrying out of rules and regulations for the enforcement of all laws designed to protect forests; and administration of all State forest lands.

Utah State constitution included the same provision regarding the forests upon State and public domain lands as that in Colorado. (See p. 23.)

1896. Utah law passed directing the State land commissioners to reserve from sale such timberlands as they deemed necessary to preserve the forests, maintain stream-flow, and aid irrigation, and prohibiting purchasers of timber on State lands from using, injuring, or destroying trees less than 8 inches in diameter, except of certain species.

Alabama code required investigation of the State's forest resources by its geological survey.

1897. Colorado abolished the office of forest commissioner and created a department of forestry, game, and fish.

Wisconsin authorized the State fire warden to appoint a fire warden in each organized town, with power to summon aid, created a temporary commission to devise plans for administration, by a forestry department, of lands of the State suitable for timber production, and required investigation of the State's forest resources by its geological survey.

Pennsylvania authorized purchases at tax sales, by the commissioner of forestry, of wild lands desirable for forestry reservations; and also created a commission to locate and acquire, with power of eminent domain, three forestry reservations of 40,000 acres each, on the watersheds of the Delaware, Susquehanna, and Ohio Rivers, respectively.

Pennsylvania made constables ex-officio fire wardens, and prescribed their duties.

West Virginia law passed requiring investigation of the State's forest resources by its geological survey.

North Dakota law established the North Dakota School of Forestry to give instruction regarding forestry science.

1899. Minnesota provided for State forest reserves and created a forestry board of nine, representing diversified interests, to manage reserves and publish forestry information.

Pennsylvania authorized the purchase of wild lands directly from the owners, at not more than $5 per acre.

Oregon provided for a State game and forest warden, with requirement that all game officials should act as fire wardens.

Missouri law required investigation of the State's forest resources by its geological survey.

1901. Connecticut law provided for a State forester, responsible to and appointed by the State agricultural experiment station board of control. Duties mainly investigative, informatory, and advisory; but limited land purchases by the forester for State forests appropriated for and their administration authorized.

Indiana created a State board of forestry, to be representative of various interests, with investigative, informatory, and advisory duties, including recommendations for State forest reserves.

Pennsylvania placed its forestry work in charge of a separate department of forestry and made the commissioner of forestry the president and executive officer of a State forestry reservation commission, to which was given authority to purchase lands for and to manage and control reservations.

1903. Indiana authorized the purchase of 2,000 acres by the State board of forestry for forest nursery and demonstration purposes.

Michigan made the State land commissioner forest commissioner ex-officio, with supreme authority in all matters relating to the preservation of the forests and the suppression of forest fires. Commissioner to appoint a deputy, known as the chief fire warden, who was given general charge of all forest fire activities in the State.

Wisconsin established a department of forestry headed by a board of five commissioners, with authority to appoint a superintendent of State forests, who should act as secretary of the board and also be ex-officio forest warden, with the duty of enforcing the State law regarding the prevention and extinguishment of forest and marsh fires.

1903. Washington made land commissioner ex-officio State fire warden. County commissioners to constitute boards of deputy fire wardens and appoint local wardens as necessary. Other wardens and patrolmen included all State land cruisers as patrolmen at large. County warden boards in timber counties to establish closed seasons necessitating burning permits. Costs of patrol and fire fighting to fall on counties. Deputy wardens required to patrol their districts, post warnings, and enforce the law.

1904. Louisiana created a department of forestry under the commissioner of the State land office as ex-officio commissioner of forestry, with additional salary, and four unsalaried members. Department to make inquiries, report on them, and recommend legislation. All State activities for forest preservation placed under control of commissioner, with power to appoint a chief fire warden. An officer in each jury ward of the State required to act as local fire warden under direction of chief fire warden, with duty of preventing and suppressing forest fires.

Massachusetts authorized the creation of the office of State forester, appointee required to have a technical education, who was to establish and maintain a forest-tree nursery at the Massachusetts Agricultural College.

Vermont required that the governor designate one member of the board of agriculture as forestry commissioner, with special duties in the administration of the provisions of the act and the protection of forests from fire.

1905. California created a board of forestry consisting of the governor, secretary of state, attorney general, and State forester; the latter was charged with the administration of the State parks, the fire protective work throughout the State, and general forest publicity work. The State forester to establish districts and appoint citizens as voluntary fire wardens, who might be paid by counties or private persons or corporations. At dangerous periods the forester might maintain a patrol at the expense of a county. Counties were required to clear inflammable material from roads at the request of the State forester.

Connecticut reorganized the forest fire protection system of the State, made the State forester ex officio State forest fire warden, and vested in him the authority, with the cooperation of town selectmen, to select district fire wardens. Each town was required to pay one half the cost of fire fighting within its boundaries, and the county and State one fourth each.

Idaho in an act regarding the sale of timber from State lands and the prevention of forest fires charged the State board of land commissioners with the duty of seeing that certain restrictions were complied with, and that brush was properly cared for when timber was cut and sold.

Illinois authorized the organization of forest preserve. districts, each comprising a portion or all of one or more counties, and gave the board of commissioners of such incorporated district very extensive powers of taxation and general administration. Displaced by law of June 16, 1909, which was declared unconstitutional December 21, 1911.

Indiana law regarding the burning of the woods required each township road supervisor to employ the assistance necessary to extinguish any fire within his district, the wages of the persons thus employed to be paid from the regular township funds.

New Jersey established a State board of forest park reservation commissioners consisting of five members; given control of State forest reserves, with authority to adopt measures of encouragement to the practice of forestry by private owners.

North Carolina enacted a new and more comprehensive law authorizing the State geologist to employ such experts and assistants as should be deemed necessary by himself and a geological board; a State forester was employed. .

Oregon made provision for the appointment of a forest fire ranger in each county of the State, to be paid by the property owners requesting such appointment. Law repealed in 1907.

Tennessee created a department of game, fish, and forestry. Nonsalaried State warden appointed by the governor, who might employ a secretary, without expense to the State, said secretary appointing county wardens and special wardens, who were given the rights, powers, and authority of county sheriffs as to the enforcement of the State laws for the protection of the game, birds, fish, and forests of the State.

1905. Washington created a State board of forest commissioners and provided for the appointment of a State fire warden and forester who should have charge of all fire protection work. The law included exceptionally detailed regulations as to fire patrol and control.

Wisconsin repealed much of the 1903 law and created a board of forestry, authorized to appoint a technically trained man as State forester, who would have supervision of all forest reserves and serve as State fire warden, with authority to appoint and remove one or more fire wardens in every town where he considered such appointment necessary.

1906. Iowa provided for an exemption of forest areas from taxation, and that the secretary of the State horticultural society act as State forestry commissioner, without additional salary, in promoting the objects of the law and in obtaining general reports upon forestry from nonsalaried county deputies, whom he was authorized to appoint.

Kentucky created a State board of agriculture, forestry, and immigration, consisting of nine members, and authorized a small sum to be expended either directly or through the United States Forest Service in advancing the forest interests of the State. Repealed in 1912.

Maryland established a State board of forestry of 7 members, consisting of the governor, 2 other State officials, 2 educators, a practical lumberman, and a citizen interested in forestry; to employ a technically trained State forester who should have charge of all forestry interests in the State, and head a State system of forest fire protection with the cost of fire fighting to be borne by the counties. Board empowered to accept gifts of land to the State for forestry purposes, and to purchase lands, with limitation as to price.

New Jersey repealed previous forest-fire laws and authorized the State forest park reservation commission to appoint a State fire warden, who was given general supervision of all forest fire protection, and to require the appointment of town fire wardens with appointment by the commissioner if the town failed to act. The entire cost of fire control on State reservations and one-half of that on other lands of any town was made payable by the State.

Ohio established a department of forestry at the State agricultural experiment station and abolished the old State forestry bureau. Cooperation with the United States was authorized, the State expenditure not to exceed the Federal.

Rhode Island authorized the appointment of a commissioner of forestry.

Vermont appropriated money for the establishment and maintenance of a forestry nursery.

1907. Alabama established an unsalaried commission of forestry comprising the governor, three other State officials, a member of the Federal Forest Service, a resident professor of forestry, and a practical lumberman, to gather and publish information as to the forest interests of the State and to recommend legislation. An optional system of county forest wardens to control forest fires was provided for.

Idaho. The law of 1905 was superseded by one which required the State board of land commissioners to divide the State into fire districts and appoint wardens upon the request of timber owners.

Kansas provided for the appointment of two forestry commissioners to reside at and have exclusive charge of the two State forestry experiment stations at Dodge City and Ogallah, each charged with the duty of disseminating knowledge about trees.

Massachusetts forest protection act required that the persons appointed as town and city forest wardens be approved by and make reports to the State forester, and authorized the payment from State funds for the services rendered by such wardens under the direction of the forester.

Michigan abolished the office of chief fire warden; duties devolved upon newly designated official, State game, fish, and forestry warden.

Oregon created an unsalaried State board of forestry, with seven members; authorized to appoint fire wardens, who were to have the powers of peace officers as to arrests. The board was given no administrative duties other than those connected with forest fire protection, and a very limited annual appropriation.

Pennsylvania enacted very strict provisions against the setting of fires on forest land, and appropriated $500,000 for the purchase of State forest reserves.

1907. Tennessee provided for the protection of public and private lands from timber trespass and from forest fires.

Texas provided for a game, fish, and oyster commissioner, the commissioner and his deputies to act as fire commissioners and to prevent and extinguish forest, marsh, and prairie fires.

Wisconsin appropriated money for the acquisition of additional forest lands at tax sales and from counties that had acquired land under tax deeds. Another law authorized an exemption from taxation of lands planted with forest trees. The State forester was charged with important administrative duties.

1908. Louisiana created a commission for the conservation of natural resources, with membership of seven.

Massachusetts authorized State forester, with consent of the governor and council, to acquire lands by purchase for purposes of demonstration in forest management; appropriation made.

Vermont State Board of Agriculture abolished and a board of agriculture and forestry created, to consist of the governor, the director of the State agricultural experiment station, and two appointive members. Required to appoint a professionally trained forester, who was to act as State fire warden, have charge of the State reserves and forest nurseries, and conduct experimental and educational work.

1909. Delaware created a State board of forestry, to consist of the governor and four other unsalaried members. The forester of Delaware College made ex officio a member of the board and also State forester, with general supervision of all forest interests of the State, direction of the activities of all forest wardens, and authority to prevent and extinguish fires. Forest wardens to be appointed by the governor and receive compensation for special services performed under the direction of the State forester. Counties were authorized to raise money for forest protection, improvement, and management, and were required to pay the full cost of fire control. All fines and penalties were available for general forestry purposes.

Idaho by amendments to the forest fire law imposed upon the State board of land commissioners additional duties as to informing the public regarding the fire laws, requiring a proper disposal of slash upon cutting areas, and cooperating with private owners in fire protection. Also provided that the State should pay its proportion of the cost of protecting timber in any district according to the extent of the timberland owned by the State in such district, in the same manner as other owners.

Kansas repealed act of 1907, and a division of forestry established at the Kansas State Agricultural College. Board of regents authorized to appoint a State forester, to have direction of all forest experimental and educational work, with the duty of assisting towns, counties, corporations, and individuals in the planting, protection, and management of timber tracts.

Maine forestry district was created as an administrative district for forest protection purposes, the forest commissioner was charged with special responsibility as to fire control therein, and a special tax was levied on all property within the district, to be used solely for protection expenses.

Michigan created public domain commission of six members. All jurisdiction over State forest affairs formerly vested in the State forestry commission and the State land commissioner transferred to the new commission; State game, fish, and forest warden to perform his duties under its direction.

Minnesota again revised the forest fire law so that the State auditor was to appoint a forestry commissioner who should be a member of the forestry board and have supervision of all fire wardens. Many amendments affecting various phases of forest fire laws.

Montana made the register of State lands, the State land agent, and the State foresters a forestry board with the duty of managing the forests of the State on forestry principles, and provided for the appointment of a trained forester who should have general control of the timberlands of the State, including fire protection, under the direction of the State board of land commissioners. County commissioners were authorized to provide money for forest protection, improvement, and management.

1909. New Hampshire established a nonsalaried forestry commission of three persons, and appointed a forester, who was also the chief fire warden, with the duty of appointing as local fire wardens men nominated by selectmen; forester was charged with the execution of all forest work of the State, including the direction of all activities having in view the prevention and control of forest fires. Forestry commission authorized to buy land for forestry purposes whenever any person or persons should furnish the funds therefor.

North Dakota created the office of forest fire warden. For unorganized townships having at least 25 percent of woodland, the board of county commissioners was required to appoint two or more wardens for each township and to designate the district of each. In each civil township in the State having at least 25 percent of its total area in woodland the supervisor was to act as forest fire warden.

Pennsylvania authorized the department of forestry to grow and distribute young trees to all persons who would plant and care for them, charge not to exceed cost of production and transportation; repealed the act requiring constables to act as fire wardens; and provided for a force of forest fire wardens distinct from the peace officers. Commissioner and deputy commissioner of forestry were made solely responsible for the forest fire protection work of the State, and authorized to appoint a district fire warden in each borough and township.

Rhode Island required the annual appointment of a forest fire warden by each town council, and the appointment of two or more district wardens if the town contained over 4,000 acres of woodland. Wardens required to take active measures to prevent and suppress forest fires.

West Virginia provided for the appointment of a forest, fish, and game warden, for a term of 4 years; to be ex officio fire warden for the State; all deputy wardens made fire wardens for their respective counties. Cost of extinguishing any fire made recoverable by the warden, in the name of the county, from the person or corporation responsible for it; such recovery not to act as a bar to the recovery of civil damages by anyone injured.

Wisconsin enacted specific regulations concerning forest fires and their causes.

1910. Louisiana authorized change of name of "Commission for the Conservation of Natural Resources" to "Conservation Commission"; membership increased to eight. Act of 1904 amended so as to designate the register of the State land office as forester, and to provide for a deputy forester who should have had technical training in silviculture. Among many new duties imposed on the forester and his assistant were general duties as to fire protection, cooperation with private parties, and authorization of the acceptance of gifts of land to the State for administration as forests by the State conservation commission. Commission authorized to purchase forest land for the State. Forest fire laws strengthened, with severe penalties.

Maryland law of 1906 regarding the appointment and duties of forest wardens (appointed by the governor upon the request of the forester, with irregular pay) was amended; one warden provided for each 15,000 acres of woodland in any county, and State to pay one half the cost of fire fighting.

Massachusetts authorized the acceptance of bequests and gifts for the advancement of the forestry interests of the State in the manner designated by the donor.

One of the striking things revealed by the legislative record is the large number of States which inaugurated activities in forestry in the years 1901–10. During the first decade of the twentieth century there was greater activity in the formation of State forestry departments which proved more lasting than in any other equal period. At the beginning of 1901, New York and Pennsylvania were the only States which had actually embarked on policies of permanent forest land ownership and administration. Not a single State had a technically trained State forester, nor were there until 1900 any technically trained foresters in the United States outside a very small number who had obtained instruction in European schools. A number of States had so-called forest commissions or forest commissioners, and the beginnings of organized fire protection had come into existence through the setting up of State fire wardens, with a greater or less degree of authority; but these State officers, of varying designations, were in the nature of makeshifts without pretense of any special expertness qualifying them for their positions. There was a very considerable general interest in forestry, but very little knowledge of what it really meant, and almost no idea of how to proceed in order to get it on its feet as a State activity.

In the decade preceding the close of the century the most important forward impulse received by the forestry movement came from the effect on men's minds of the terrific forest fires of the period, particularly in the Lake States, where the losses both in property and human life were appalling. In the first decade of the twentieth century, on the other hand, there was developing a better public understanding of forestry and a wider and keener interest in obtaining its application. The oldest professional school of forestry in the country, Cornell, turned out its first graduate (a single one) in 1900, and the second oldest, the Yale School of Forestry, its first graduating class of eight men in 1902. Practically simultaneously with the creation of means of educating a supply of young foresters, the Federal activities in forestry began to expand and attract public attention. The preliminary stirrings which presaged the oncoming of the conservation movement were beginning to be felt. With the accession of Theodore Roosevelt to the Presidency came the real opportunity for a great burst of progress. The States were looking to Washington for ideas and guidance, and under the influence of what was happening at Washington, State forestry began to take shape in enduring and useful forms.

To this reliance upon outside leadership Pennsylvania was an exception. Like New York, its forestry movement, while gaining power from the stimulus of the general forestry movement, was essentially indigenous. The principal credit for it belongs to one man, Dr. J. T. Rothrock, who practically gave his life to it. Its most outstanding accomplishment has already been pointed out.

The States which turned to Washington for advice regarding the form of organization which they should set up to take care of their forestry interests received recommendations which embodied two principles as fundamental: (1) That their laws should provide for a technically trained State forester in charge of the work, and (2) that his position and entire organization must be nonpolitical. To assure an administration of the State forestry interests not dominated by political considerations, the States were advised to make their forestry departments independent of any existing department, such as departments of agriculture, land departments, and fish and game departments, and to make the State forester responsible to a directive board made up of representatives of organizations and institutions within the State of a kind to promise a capable and disinterested governing agency concerned solely with serving the public as well as possible.

An example is the board created by the Minnesota law of 1911. Following disastrous forest fires in the previous year, Minnesota then radically revised its forestry law. The chief executive officer was to be "a State forester who shall be a trained forester." He was to be appointed and his work directed by a State forestry board of 9 members, of whom 1 was to be the director of the forestry school and 1 the dean of the Agricultural College of the University of Minnesota; 2 were to be appointed upon the recommendation of the regents of the university and 2 more upon the recommendation of the Minnesota Forestry Association; the other 3 were to be appointed upon the recommendation, respectively, of the State agricultural society, the State horticultural society, and the State game and fish commission.

Generally speaking, the State forestry departments which were created in the decade 1901–10 started off as principally agencies for gathering and disseminating information and performing an educational function with respect to forestry and its possibilities, partly through practical advice to landowners. State forestry had to feel out its way and make its own place. The State foresters were young men, their pay was small, and the interest of State legislatures in their undertaking slight. To obtain authority for its expansion and increased funds for its strengthening was slow and uphill work. Most politicians found little account in giving it backing, unless public demand made action expedient for them; and public opinion unless organized and led by men of determination and good judgment registered only spasmodically, if at all. There was little inclination anywhere, except in New York and Pennsylvania, to inaugurate policies looking to extensive undertakings of public forest ownership and administration. Nor was there in most States any strong desire to create a centralized, efficient system for the control of forest fires. The function of protecting privately owned forest property against fire, it was prevailingly thought, should fall to the owner rather than be undertaken at public expense; and to the extent that some means was needed for organizing and leading collective effort to control fires which threatened to spread widely, local wardens not tied in or at most only tenuously tied in to the State Forester's office were supposed sufficient.

There was one striking exception to this. In the Northwest, where yearly fires were doing great damage and enormous holdings of private timber were being built up, the unprecedented fires of 1902 accelerated a movement to obtain organized protection. In Washington and Oregon this movement at first took shape along much the same lines as in the East. The Oregon law of 1899, imposing on the State's game officials the duty of acting as forest fire wardens, and the Washington laws of 1903 and 1905 have been indicated above. In 1903 Governor Chamberlain vetoed, in Oregon, a law similar to that passed in Washington during that year, on the ground "that it called for a small appropriation." In 1905, however, Oregon passed a law requiring the county courts to appoint as fire rangers the persons named by one or more property owners desiring protection from fire. The cost of the rangers was paid by these property owners. This established the principle of fire protection maintained with the backing of public authority but at the cost of those desiring it.

Protection of his property by each individual timberland owner was both unnecessarily costly and of limited value, since fires paid no regard whatever to the invisible boundary lines between holdings. To provide for joint systems of protection, western timberland owners devised the method of uniting for the maintenance of protective associations. The first timberland owners' protective association was formed in Idaho in 1906. The idea was quickly taken up in Washington and Oregon. These associations obtained funds for maintaining their several protective organizations by assessing their members, on an acreage basis. But there was no way to bring in owners who did not wish to share in the expense, although to protect the property of their members the associations were compelled also to protect intermingled or adjoining lands.

To meet this situation, the four northwestern States of Montana, Idaho, Washington, and Oregon eventually enacted laws which, while varying considerably in detail, embodied as their fundamental principle the requirement of contributions, in proportion to acreages, to support the protective organizations, from all the owners whose properties received the benefit. Where the State had land of its own to be protected, the State paid its share just like any other owner. Virtually, the associations became recognized agencies of the State for performing the protective function. They selected and employed the personnel of the organization, and managed it. Thus it came about that in the Northwest most of the cost of fire protection was met by the landowner, as such.

In developing their protective systems the associations were aided greatly by the progress in building up efficient systems of protection on the national forests dating from early in 1905, when the present Forest Service took charge of them. In place of the idea of wardens with the duty primarily of calling out forces of fire fighters and acting as leaders to bring the fire under control, came the idea of the ranger, with duties of patrol and functions of detection and prevention as well as of suppression. In place of the primitive, catch-as-catch-can fire fighting of the early days came the methodical development of procedure and organization that was to evolve into the modern highly specialized technique of large-scale operations in suppression. Not only were the protective associations assisted by being able to make use of methods developed by the Forest Service; where association lands were intermingled with or adjoined Government lands within the national forests, direct cooperation became possible, and mutually advantageous. Prior to 1911, the Northwest was the section of the country in which real progress was made in providing organized protection against fire as a State activity.

When the second decade of the century opened (that is, at the beginning of 1911), 25 States had forestry organizations of some kind, though in only a minor fraction of this number were trained foresters in charge. As a rule, the function of the State forester, where there was a trained man, was still mainly to give advice to forest owners, gather information on the forest resources of the State, their utilization, State timber requirements, and kindred matters, and carry on a campaign of general education concerning forestry. Except in New York and Pennsylvania, the financial provision for the work of the State forestry department was everywhere very meager and the organization for carrying on the work too small-scale to function in a really important way, beyond laying the foundations for more substantial activities as State forestry really found itself, in the next decade.

THE EFFECT OF THE WEEKS LAW ON STATE FORESTRY

On March 1, 1911, Congress passed the Weeks law. Section 2 of this law appropriated $200,000 to enable the Secretary of Agriculture to enter into cooperative agreements with the States in order to protect from fire the forested watersheds of navigable streams. The cooperative agreements were to provide for the organization and maintenance of a system of fire protection organized in accordance with State laws, manned by State appointees, and supported financially by the State and the Federal Government jointly, on condition that the State should contribute not less than half the total cost.

Table 1 shows the growth of State fire protection under the Weeks law and the amendatory Clarke-McNary law of 1924, from 1911 down to the present time:

TABLE 1.—*The growth of Federal-State cooperative forest fire protection, calendar years 1911–1931*

Year	Number of States cooperating	Funds expended			Area under protection
		Federal	State	Private [1]	
					Acres
1911	11	$36, 692	$165, 975	$54, 590	60, 779, 000
1912	12	51, 069	168, 319	65, 439	68, 279, 000
1913	17	67, 414	356, 144	246, 761	82, 678, 000
1914	17	82, 193	427, 615	201, 999	94, 678, 000
1915	20	69, 134	487, 795	329, 548	98, 388, 000
1916	20	79, 702	400, 742	291, 651	103, 562, 000
1917	21	82, 733	537, 272	659, 052	104, 062, 000
1918	23	92, 515	555, 587	301, 308	109, 562, 000
1919	24	85, 706	718, 555	1, 366, 749	128, 812, 000
1920	24	92, 921	972, 379	1, 027, 087	140, 204, 000
1921	25	265, 522	1, 494, 831	876, 826	165, 801, 000
1922	26	387, 008	1, 759, 718	1, 971, 777	175, 000, 000
1923	26	325, 549	1, 759, 207	1, 454, 094	(2)
1924	28	397, 357	1, 662, 532	1, 850, 862	(2)
1925	29	414, 829	1, 815, 094	1, 204, 583	178, 200, 000
1926	33	654, 099	2, 009, 415	1, 936, 286	195, 200, 000
1927	34	704, 748	2, 005, 522	1, 368, 992	202, 100, 000
1928	38	1, 256, 225	2, 062, 687	1, 272, 693	213, 106, 000
1929	38	1, 208, 988	2, 804, 818	1, 982, 426	223, 973, 000
1930	38	1, 389, 121	3, 899, 644	1, 705, 975	227, 551, 000
1931	[3] 38	1, 532, 944	3, 839, 305	2, 056, 264	227, 611, 000

[1] Private expenditures previous to 1917 probably understated because complete data for earlier years are lacking.

[2] Data lacking.

[3] Includes Territory of Hawaii.

The workings of the laws under which Federal cooperative aid has been extended to the States will be fully discussed in the chapter of this report entitled "Federal and State aid." For the purpose of the present section, all that is called for is a brief indication of the part that this law has played in shaping the development of State forestry, determining its set-up, crystallizing its program, and giving it its present capacity for further development and future usefulness.

The immediate effect of the Weeks law was to make the administration of fire protection a recognized field of activity for the State forestry departments generally. It gave them something specific to do, and the same thing to do everywhere. The whole trend of State forestry was given thereby a new direction. The influence exerted by the Weeks law was by no means due solely to the opportunity that it held out to obtain Federal money and the resulting stimulus to enlarged State appropriations for fire protection. The law embodied a principle the validity of which many State legislatures had up to that time been hesitant to accept. Always, of course, any proposal for a State to enter upon a new form of public activity encounters the resistance of inertia and conservatism. Reluctance to set up a new form of demand upon the State treasury that will be bound to grow greater is not only understandable, but a course of prudence, unless the justification of the new undertaking is clearly seen. That the cost of protecting forest properties in private ownership against damage by fire should be borne in whole or in part by the public, because public values and public interests were involved in addition to the property interest of the private owner, was a principle which, following the passage of the Weeks law, rapidly gained general acceptance. Federal leadership in laying down the principle largely brought the change. Not only did the law cause the States which had forestry departments to assign them the function of administering organized fire protection; the attention of other States was attracted, and as the benefits and practicability of fire control became clearer many new States set up systems and created forestry departments primarily for this purpose. In consequence, outside of New York and Pennsylvania, where land administration had from the outset held a leading place in the State's forestry work, the administration of fire protection has been the backbone of State forestry.

Federal cooperation influenced and strengthened the State forestry departments, however, in other ways than by leading them into fire protection and helping finance it. The Federal cooperative funds were not in the nature of a subsidy to State enterprises of fire protection. They were made in recognition of definite national interests and purposes to be served, in addition to purely State interests. Therefore, the way in which the money was used was a matter of direct Federal concern. Failure on the part of a State organization to function efficiently would not only constitute a waste of funds supplied in part by the Federal Government, but also would mean a falling short in the attainment of the national objective of the law. The duty therefore devolved upon the Forest Service, as the agency charged with administration of the Weeks law on behalf of the Federal Government, to inspect the workings of the State systems and do its best to help bring them to as high a standard of efficiency as possible. The Forest Service was able to be of assistance to the States in their effort to build up good systems of fire protection principally in three ways.

As the agency charged with the duty of protecting the national forests, the Forest Service had been compelled to study intensively the whole fire problem and was making steady progress in the development of the technique of fire control. Its ability to serve as adviser was increased by the fact that, coming into contact with the work in all the cooperating States, it was able to bring to bear on each State the experience that was being gained elsewhere. It was also a means of strengthening the hands of the State foresters against political pressure to put or keep on the pay roll inefficient men.

THE PRESENT STATUS OF STATE FORESTRY ACTIVITIES

STATE ORGANIZATIONS

In 42 States there is now legal provision for carrying on forestry activities, and in most of them a distinct forestry organization is set up. In a few instances it is one of several divisions of the Conservation Department, in others it is subordinate to some other State administrative board, commission, or commissioner, and in still others it is independent of other State activities but subject to some control by an appointed board or commission. Experience has demonstrated that a set-up which involves the field force of the State forestry organization in such other activities as the enforcement of the game and fish laws tends to react against its success in its own particular field of forestry. This set-up is most likely to be attempted when the State forestry department is one of the divisions of the Conservation Department. Further than that, under this form of organization, the development of the forestry work may be and sometimes has been hampered by a lack of sufficient interest in it or understanding of it on the part of the Conservation Department head or heads, chosen primarily to administer other activities.

A forestry board or commission which serves in a directive capacity, formulates policies, sets up a program, and strives for means to accomplish it, but does not concern itself with or interfere with the choice of personnel other than that of State forester, is a very workable form of State forestry organization. It bears the same relation to the State forestry enterprise that a board of directors does to a successful business enterprise. A board of this type appointed by the Governor with terms of office the same as his own, however, is likely not to serve the best interests of forestry. A board whose personnel is entirely or largely fixed by law may be good, but it is not ideal; ex-officio members of boards may be too busy with other affairs to take an active part, or may not be particularly interested in forestry. But with conditions as they are in politics in some States today, it is probably best, if not essential, to make the composition of the board definite. Preferably, the board members should serve for staggered terms so arranged that any one administration cannot preponderantly alter its composition, and should choose their own chairman. Some States have such boards today. This board structure conduces to the choice of strong and interested men, and assures continuity of policy. While the board may have some political tinge, this can be a source of strength to the forestry cause rather than a weakness.

Table 2 indicates how State foresters are appointed. Only in New York must the selection be in accordance with a State civil service law. The State foresters however are as a rule selected on a basis of fitness, and retained as long as they remain effective and their relations with their boards of superiors continue harmonious. They are ordinarily subject to removal for administrative reasons, as would be true in any efficient business organization. Nevertheless, the removal from office of State foresters on political grounds has sometimes taken place, and is a real danger to the maintenance of the work on a high level of efficiency. State civil-service protection to the year-long staff other than the State forester is provided in California, Maryland, Massachusetts, New Jersey, New York, and Wisconsin.

TABLE 2.—*Characteristics and composition of State forest organizations, 1932* [1]

Region and State	State forester														Other year-long personnel with civil-service rating	Composition of organizations			
	Provided for	Appointed by—			Requirements		Tenure of office		Relation to other State organizations							Year-long		Part time	Total
		Governor	Other official [2]	Board [3]	Technical training	Civil-service rating	Indeterminate [4]	Term	Independent	Subordinate to—						Technical	Non-technical		
										Conservation Commissioner	Board of Forestry	Board of Conservation	Commissioner of Agriculture	Other board					
								Years								*Number*	*Number*	*Number*	*Number*
United States total																327	1, 310	25, 659	27, 296
New England:																			
Connecticut	X			X	X		X				X					6	15	802	823
Maine	X	X						4	X							13	4	874	891
Massachusetts	X	X						3	X						X	9	96	2, 709	2, 814
New Hampshire	X			X			X				X					4	10	832	846
Rhode Island	X		X				X					X				1	2	164	167
Vermont	X	X						2				X				8	2	318	328
Total																41	129	5, 699	5, 869
Middle Atlantic:																			
Delaware	X			X	X		X				X					1	2	40	43
Maryland	X		X		X		X							X	X	7	7	700	714
New Jersey	X			X			X			X					X	18	79	365	462
New York	X			X		X	X			X					X	57	265	2, 652	2, 974
Pennsylvania	X		X					4	X							61	170	4, 000	4, 231
Total																144	523	7, 757	8, 424

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[1] Exclusive of Arizona, Nevada, New Mexico, Utah, and Wyoming in the Southern Rocky Mountain region in which States no State forester or similar officer has been provided by law.

[2] Usually a director or commissioner.

[3] Includes commissions of several types.

[4] Includes officers held during good behavior, during satisfactory service, and those held during the pleasure of appointing boards or other groups.

TABLE 2.—*Characteristics and composition of State forest organizations, 1932*—Continued

Region and State	State forester															Other year-long personnel with civil-service rating	Composition of organizations			
	Provided for	Appointed by—			Requirements		Tenure of office		Relation to other State organizations								Year-long		Part time	Total
										Subordinate to—										
		Governor	Other official	Board	Technical training	Civil-service rating	Indeterminate	Term	Independent	Conservation Commissioner	Board of Forestry	Board of Conservation	Commissioner of Agriculture	Other board			Technical	Nontecnical		
South:								*Years*									*Number*	*Number*	*Number*	*Number*
Alabama	X	X			X		X				X						5	5	58	68
Arkansas	X			X	X		X				X						0	0	0	(5)
Florida	X			X	X		X				X						11	14	18	43
Georgia	X	X			X		X					X					12	11	16	39
Louisiana	X			X	X			4		X							1	298	0	299
Mississippi	X			X				4			X						4	6	15	25
North Carolina	X			X			X			X							7	52	4,000	4,059
Oklahoma	X			X			X				X						4	11	24	39
South Carolina	X			X	X		X				X						6	1	0	7
Texas	X			X	X		X							X			6	13	236	255
Virginia	X			X	X		X			X							11	5	1,400	1,416
Total																	67	416	5,767	6,250
Central:																				
Illinois	X			X				2		X							2	7	10	19
Indiana	X		X				X			X							6	4	2	12
Iowa	X	X						2	X								0	0	0	(6)
Kansas	X			X			X							X			1	1	0	2
Kentucky	X		X		X			4					X				3	9	11	23
Missouri	X			X				2						X			0	0	0	(7)
Nebraska																	0	1	0	[8] 1
Ohio	X			X			X							X			11	29	625	665
Tennessee	X			X	X		X						X				7	2	4,000	4,009
West Virginia	X			X	X		X					X					3	6	890	899
Total																	33	59	5,538	5,630

Lake:																			
Michigan	X			X			X			X						2	14		16
Minnesota	X		X		X		X				X					16	85	150	251
North Dakota	X		X				X							X					(9)
Wisconsin	X	X					X			X					X	7	8	200	215
Total																25	107	350	482
North Rocky Mountain:																			
Idaho	X			X			X							X		0	3	0	3
Montana	X	X			X			4						X		3	4	15	22
Total																3	7	15	25
South Rocky Mountain:																			
Colorado	X			X	X		X							X		3	0	0	3
South Dakota	X			X			X							X		0	1	1	2
Total																3	1	1	5
Pacific coast:																			
California	X		X		X		X				X				[10] X	6	46	140	192
Oregon	X			X			X				X					3	18	12	33
Washington	X		X					4		X						2	4	380	386
Total																11	68	532	611

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[5] Arkansas has provided no funds to fill the office.

[6] Secretary of the Department of Agriculture is the State forestry commissioner, inactive.

[7] No funds, 1932.

[8] Forestry work under the direction of the director of the conservation and survey division of the University of Nebraska.

[9] Office of State forester is filled by the president of the School of Forestry, at Bottineau. Not counted in this tabulation.

[10] Chief and assistant chief of division do not have civil-service standing.

Strength is given to the organization in 18 States by the legal provision that the State forester shall be a technical forester; in 24 States there is no such requirement. The provision for a technical forester is most striking in the southeastern group of States; it is noticeable by its absence in five of the six New England States. Although the laws of 24 States do not provide for technical foresters, the present incumbents in 11 of those States, Indiana, Michigan, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, Vermont, and Wisconsin, are technical men.

Salaries of State foresters and their staffs conform pretty much to State standards. For State foresters they vary from $1,800 to $8,000, with a majority running from $3,000 to $5,000. In lower administrative positions the salaries range from $1,200 to $3,000; some exceed the last figure. In many States they are inadequate to hold men of the caliber needed to meet the higher responsibilities or to attract technically trained men to the arduous but less responsible positions and retain them until they can be advanced. In these States the salary scales must be readjusted if the brains, experience, and stability essential to successful functioning of the organization are to be looked for.

That the State forestry departments are attempting to build up their organizations with technical men is indicated by the number employed, 327 in all. Pennsylvania leads, with 61, and is followed by New York, with 57. The preponderance of such men in these two States is to be expected, because they have acquired and are administering large areas of forest lands; technical men are essential to the successful development of forest lands.

The number of part-time men employed is of significance in one respect. They are usually fire wardens who function only during the forest fire season. The number of such wardens is partly indicative of State-wide interest in the control of forest fires and partly of large areas of forest land in need of protection. The outstanding States in this respect are Pennsylvania, North Carolina, Tennessee, Massachusetts, New York, and Virginia.

Nearly all the State organizations begin with a mere skeleton force in State employ. County or town officers have commonly been previously charged with the duty of suppressing forest fires by State law or local custom. At the outset, the State forester has in some cases been expected to rely on these local officers with the skeleton force under him engaged mainly in assisting or nominally supervising their efforts. Such a form of organization is highly unsatisfactory. When the State forester either appoints the county or town forest-fire officers or has the authority to disapprove and reject such men if unsatisfactory, the organization is strengthened tremendously. Even under this arrangement, however, elements of weakness are likely to show up with serious if not tragic consequences in periods of extreme forest-fire hazard and forest-fire occurrence. This leads to a gradual assumption by the States of the entire responsibility and often the entire burden of forest-fire protection. It is a normal trend in the interest of efficiency, and will be accentuated as time goes on.

The State organizations as a whole have able men at their heads; their field force, when not subject to political control, is as competent for its job as can be expected, sometimes more so, when the salaries paid and the meager number of men employed are considered. Fire protection has been the principal job, and with experience the men have become proficient in it.

Administration and development of State forests has been given secondary consideration. It is the more difficult job of the two, because it requires men with techncal training and a longer time to learn. It demands more intensive study, careful observations, and closer supervision than it has had in the past. It is going to necesssitate greater emphasis on State effort in this direction, and even realinement of personnel in some State organizations, if the job is to be coped with successfully.

Due to lack of appropriations, some State organizations are, of course, woefully undermanned. A limited number are just about built up to the point in quantity and ability of personnel to handle the State's forestry problems in a satisfactory manner, and it can be expected they will do so. More will arrive at that situation in a few years. For others, where favorable public sentiment toward forestry is not as yet well developed, and where the State's wealth is disproportionately small, the outlook is not so cheerful. A long period of intensive educational effort is indicated, during which a careful and thorough administration of the type of work that can be undertaken must be the primary aim.

As a rule, the laws authorize the State forestry organization or its administrative officers to carry on a wide range of forestry activities, such as to maintain a system of fire protection, to assist the private owners of woodland, to ascertain facts about and make reports on the State's forest resources, to cooperate with the Federal Government, to grow and distribute forest trees for planting, and to acquire forest land through one means or another and administer it as State forests. In a few instances, certain activities such as purchase of land for State forests and the growing and distribution of trees to private owners are not permitted. The extent to which the States engage in these various activities and the degree of success attained is largely determined by the State funds appropriated for the various purposes.

The general trend in State organization is to divide the States into districts and to put a man in charge of each. With aid, supervision, and inspection from headquarters, these men handle most of the various State activities in their districts, especially protection, reforestation, and management of State lands. Some States have gone further than others in decentralizing these activities and in delegating authority to the district men. Educational activities and legal matters are ordinarily handled by or are under close supervision of the central office, and of course policies and programs are decided there. Extension activities are logically a function of the district men and are handled by them when they are technically qualified for the task. Otherwise, this field is covered by the headquarters organization.

THE PROMOTION OF PRIVATE FORESTRY

The chief purpose of most State policies of forestry is to bring about private timber growing. Policies of extensive permanent forest ownership and management by the States are still exceptional. While forest protection, forest research, nursery production of planting stock, and public education in forestry are all necessary for successful public forest management, and while in the States that are engaging in forest management these activities serve both purposes, it will not do violence to the general situation to regard them as conducted primarily to promote private forestry.

Initially, many of the State forestry organizations were created as agencies for gathering and diffusing information that would acquaint forest owners and the public generally with the methods of, the need for, and the returns obtainable from forestry. This was particularly true prior to the passage of the Weeks Law in 1911, which offered Federal cooperation in maintaining organized protection against forest fires. Following the pattern set up for them by the Bureau of Foresty in Washington before it was placed in charge of the national forests, the State foresters undertook to gather information on the forest resources and forest industries of their several States, the requirements and markets for the various classes of forest products, the damage done by forest fires, rates of growth, desirable practices of forestry, and the like.

Since the science and art of silviculture as applied to American conditions had hardly begun to be built up, they had to learn as they went along. Partly as a means of gaining experience, partly as a means of diffusing knowledge of the principles of forestry, they commonly offered to give private owners advice on the care of their woodlands. In this also they were influenced by the example of the Federal Bureau of Forestry. Above all, they had to quicken public sentiment into vigorous life against uncontrolled forest fires. Thus functions of research (if the early unsystematized fact gathering may be so termed), of public education, and of extension either preceded or developed along with the assumption of administrative responsibilities. This was true particularly in the East.

EDUCATION AND EXTENSION

Public education in forestry is still and will continue to be an important function of a State forestry organization. An intelligent public opinion based on widely diffused knowledge of the objectives and methods of forestry is essential for the best use of the forest resources. The story of what forestry is and of its aims and public welfare aspects must be told over and over. The scope of the State work, what and where its current activities are, what more it might do, the problems confronting it, how the public can help, desirable legislation, and regulatory provisions of the forestry laws are all subjects of real public interest. In proportion to the degree that the purposes served by a State forestry organization are of public benefit, public support will be accorded if the facts are generally known. The rate of progress in State forestry is largely dependent upon how successfully the State forester can take on a function of leadership. Educational activities are of vital importance in meeting the problems of State forestry.

Numerous means are open. The State forester must use many avenues of approach if all classes of the public are to be informed. There are great differences in the amount of attention given to educational activities by State organizations. In part this is because some have more resources to work with, either in money or in the form of better speakers and writers in their organization. In part it is because of a better appreciation of the value of educational effort.

The most important single means of popular education in forestry matters is without doubt the press. The daily and weekly newspapers reach people in all walks of life. In some States prepared news bulletins are furnished for the newspapers of the State.

State foresters are often given an opportunity to speak over the radio. Some radio stations also broadcast the so-called fire weather reports, warning the public when the weather for the day will be very dry and conducive to forest fires. Public addresses by State forestry officers are among their duties, and are widely used as a means of education. Frequently the speaker can use lantern slides or moving pictures, of which some States own their own films. New York State in 1931 had films covering 30 different titles. There is such a wide call for addresses of this kind that it has been necessary in New York to restrict addresses to audiences where there will be at least 200 people.

In their every-day personal contacts with the public, the State forestry employees are constantly performing an educational function. Observers on the fire lookout stations are often proivded with postal cards and other printed matter, to hand interested visitors. Some States require their field men to wear a uniform, which calls attention to the work and the fact that the State is engaged in it.

In several States special efforts are made to reach boys and girls in summer camps, children in the schools, and people not easily reached through ordinary channels. Several of the Southern States in cooperation with the American Forestry Association put on a special 3-year educational campaign among the country people who lived in the wooded sections. Trucks which carried their own moving-picture equipment and lecturers were employed for that purpose. Pennsylvania as long ago as 1926 had enlisted in an organization known as the Forest Guides of Pennsylvania 25,000 boys, who were pledged to help protect the forests of the State and to urge others to do so.

Exhibits at fairs are a common means used to arouse interest, both through the exhibit itself and through the man in attendance. These exhibits take many and ingenious forms. The posting of signs and the publication and distribution of bulletins afford means of reaching large numbers of people. Pennsylvania in one 2-year period distributed more than 400,000 copies of publications, covering many phases of forestry work.

Demonstration methods are beginning to be used, with good results. Several States have set up roadside demonstration plots, conspicuously signed. Pennsylvania and Connecticut lay out "blue-ribbon plots." The trees most suitable for the final crop trees are selected and marked with a band of blue paint. Trees which if left would interfere with the growth of the final crop trees will be cut out as they can be marketed. These plots have excited a great deal of curiosity; signs are placed to indicate their purpose and they have thus become of educational value.

The laws of Georgia, Louisiana, Mississippi, North Carolina, and Tennessee require the teaching of forestry by the regular staff of teachers in the primary or advanced public schools or in both. In Ohio, South Carolina, and West Virginia provision is made by law for the State board of education in each case to prepare a course of study in fire prevention, which presumably includes protection of forests from fire. This course is for use in public, private, and parochial schools of the State. Tennessee led in requiring that forestry must be included in the public-school curriculum. Its legislation on this subject dates back to 1921. It was closely followed by Louisiana in 1922.

State colleges or universities with courses leading to a degree in forestry are found in California, Colorado, Connecticut, Georgia, Idaho, Indiana, Iowa, Louisiana, Maine, Michigan, Minnesota, Montana, New Hampshire, New York, North Carolina, Oregon, Pennsylvania, Utah, and Washington. In New York, Pennsylvania, and Washington, State institutions provide courses of instruction for forest rangers.

Elementary courses in forestry are provided by universities and colleges in Alabama, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Hampshire, New York, North Carolina, North Dakota, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Utah, Vermont, Virginia, Washington, and Wisconsin.

Forestry extension is another type of State activity. By forestry extension is meant those activities directed toward assisting the private owner in handling his forest land. Of necessity the State forester is obliged to give time to this activity, even if it is only by correspondence and the preparation and distribution of publications, because he is certain to be called upon for this kind of service. There is no measure of the time and effort which forestry extension entails, but in the aggregate it is very considerable. It is a popular type of service, and it is the means of inaugurating forest management in wooded areas here and there throughout the State. If it could be developed to the utmost of its possibilities, it would constitute perhaps the greatest service that could be rendered to private timberland owners. At the present time in most States dual organizations are handling it, and for the most part too restrictedly. The first is the State forestry organization; the second is the extension service of the State agricultural colleges. The latter is limited to farm forestry extension. The State forestry organizations for the most part have not been built up to the point in number of men where they are able to meet the demands for help. The State extension services are weak also in the number of foresters employed (one forester ordinarily has to cover the whole State) and too frequently the work is hampered by a lack of training and experience in forestry on the part of the county agents upon whose shoulders lies the major burden of agricultural extension work. They are capable men, but extremely busy with many other agricultural subjects. Hitherto, in their conception of a county agent's job, attention to timber as a farm crop has been likely not to find as much of a place as it merits.

In a number of States there has been a definite effort by the State foresters to foster the extension work. In Maryland at least it is a major State forestry activity. Maryland has long made a specialty of assisting private woodland owners. General examinations and recommendations for handling private forest tracts are made entirely without cost to the landowner. If an estimate of the timber and its value is requested, if a sample marking is made, or if a contract of sale is prepared and the owner furnished with a list of probable buyers for his product, a charge for the forester's services is made of

$3 a day plus his expenses up to three days; thereafter $8 a day is is charged for his services. The $3 is about half of the actual cost to the State, but the work is regarded as a forest demonstration in which the State is glad to share the cost. During the year 1929 examinations were made and recommendations formulated for 50 pieces of woodland, comprising nearly 13,500 acres; these were scattered in 18 counties. During the same year more intensive service was given on 6 operations covering 143 acres located in 4 counties.

The 1929 report of the State forester of Maryland speaks of this work as follows:

> Numerous examples are on record where individual owners have been benefited, according to their own estimates, to the amount of thousands of dollars by the service given at a nominal cost.

This statement can unquestionably be accepted at full value. Twenty-four of the States make these field examinations. From 1920 through 1925 (later data are not available) the Pennsylvania State forestry organization examined 1,939 tracts, aggregating 386,749 acres. From Virginia comes the statement that the demand for this type of work has been too great to meet with the present personnel.

Without doubt that is the situation in a great many States. It will be remedied as State appropriations increase and State-wide organizations are completed. Pennsylvania today, through its wide-flung State organization, is probably better equipped than any other State to handle this activity effectively. The organization in New York State is rapidly being built up to the point where it can do so. It seems that it will be only a question of time until all States which are actively engaging in forestry will have built up a State force under which district foresters will have charge of all State activities, each within a certain described region. When that situation comes about forestry extension will undoubtedly be one of the important jobs of each district forester.

Within their prescribed field, the State extension foresters, who are supervised by the directors of extension at the State colleges of agriculture, are carrying on forestry extension as well as their small numbers and funds permit. Some have shown exceptional ability. Their activities are limited to the farm woodland owner. Under the present set-up at least they are not expected to assist other timberland owners. The activity of these men is made possible by Federal funds, and they are given some Federal supervision. This phase of extension is described under the section Federal Financial and Other Direct Aid to the States. The Federal aid to the States for extension work under the terms of the Smith-Lever, Capper-Ketcham, and Clarke-McNary laws and direct Federal appropriations for extension work amounts to over $10,000,000 annually. Of this amount only $70,000 is allotted for farm forestry extension. State funds for the same purpose total about $90,000.

Considering that the forest area in the United States is substantially greater than the area in cultivated crops, and that the production of forest crops is a matter about which most people know very little, these appropriations are in striking contrast. There is a decided lack of balance when, as in the Upper Peninsula of Michigan, although only 5 percent of the land is in cultivated farm crops, almost the entire extension effort has to do with these crops. Forestry extension is still operating on a shoestring, and is therefore entirely unable to take its rightful place in the general scheme of agricultural extension. There is a further weakness in the fact that forestry extension specialists receive most of their supervision, advice, and direction from men not intimately familiar with forest practices and forestry aims. Being attached to a service which has little primary contact with the forest problem, the extension forester is often detached from the general current of forest ideas. An additional difficulty is that most of his work is done through county agricultural agents, 4-H Club leaders, and to some extent home demonstration agents, whose time is too fully occupied with other projects to leave room for much attention to forestry unless their interest in it is rather exceptional. Few county agents have had the kind of training necessary to give them a balanced land use attitude or a practical understanding of the methods of forestry. The State colleges might well give more care to seeing to it that those preparing for county agent work in the naturally forested regions receive specific preparation for farm forestry work. In Louisiana this is now required.

The forestry extension specialist is supposed to work in cooperation with the State forestry department and in many if not most cases he does so freely and fully, but the contact is usually not close enough to obviate the danger that two independent agencies will be engaged on the same forestry problem, with insufficient coordination of effort and advice. This danger should by all means be averted. It can be if the work of the forestry extension specialist in each State and the work of the State forestry department can be closely enough correlated.

The full field of forestry extension includes not only farm woodland owners but other timberland owners. An adequate extension set-up would require provision for reaching both effectively, under a unified plan. With such a set-up, Federal funds for forestry extension could well be increased in some proportion to the magnitude of the area and the problems confronting the forest owner.

RESEARCH

When it began to appear, as the nineteenth century wore along, that the country would be faced with a forest problem of large proportions, the need for better knowledge of our forests, forest resources, and forest requirements was borne in upon most of those who gave the subject any attention at all. This was the more natural because the forestry movement of the latter half of the nineteenth century was greatly influenced by scientific thought, was largely led by scientific men, and was promoted by scientific organizations.

DEVELOPMENT AND FUNCTIONS OF FOREST RESEARCH

The most outstanding fact in the early situation was that no one knew what ought to and could be done. That the forests of the country were being destroyed, that the current practices of utilization must somehow be altered, that timber growing must be brought about to provide for future requirements, and that some form of public action was needed were matters concerning which intelligent opinion tended to coincide. But when it came to practical remedies, everything was involved in uncertainties.

There was not even an approach to knowledge of the amount of standing timber in the United States, the rate at which it was being cut, the drain through fire and through natural causes such as disease and insect attacks, and the rate at which the supply was being replenished through growth. There was no basis for a conclusion as to what the future needs of the country for wood and other forest products would be. The whole subject of forest influences upon climate, water supplies, the regimen of streams, the navigability of rivers and harbors, the rate and character of erosion, and the relationships between the forest and wild life of various kinds was practically unexplored. Popular opinion on some of these matters was pretty well formulated, in a broad way, but was based wholly on unverified generalizations derived from common observation or on European thought.

Future forests and forest products supplies were supposed to depend largely on tree planting, commonly called "forest culture" and considered to be akin to horticulture; but many and difficult technical problems had to be worked out before artificial reforestation on a large scale could be successfully undertaken. Regarding the art and science of silviculture as applied to the management of established forests ignorance was abysmal. Even the make-up of the American forests—the relative representation of tree species, the complete list of the native trees, the character of the undergrowth, and the relative representation of age classes—was very imperfectly known. Similarly, what the wood of these species was good for and how to use to best advantage the many kinds of wood at hand were matters that had never been made a subject of careful inquiry; men were satisfied to take the cream, wastefully, and to use it wastefully, governed chiefly by the ease and cheapness with which it could be obtained, handled, and worked, and by its general high quality.

Hence the form of public action to which those solicitous over the forest problem of the country naturally turned first was the building up of better knowledge. One of the subjects of inquiry, it was seen, should be the economic aspects of the problem—how much timber there was in the country, and where; how fast it was being used up, and for what purposes; whether a future shortage must be looked for, and if so, how soon; timber exports and imports; and so on. Another subject of inquiry was the forest itself as a biological and geophysical entity; the natural laws governing its distribution and behavior, and its influences. A third concerned methods of use and the cultural practices necessary to perpetuate the forest as a resource or to provide new forests. It was to serve these purposes that Congress first made provision for the conduct of investigations by the United States Department of Agriculture; and it was chiefly for these purposes that the States inaugurated their early work in forestry. In other words, public forestry at the outset was primarily in the field of what, with some qualifications, may be called research.

Research is a term often loosely used nowadays to denote almost any fact-gathering activity, however trivial and even mechanical its character and however practical its object. Research is of course the pursuit of new knowledge. Whether its ultimate object is utilitarian or to obtain new knowledge as an end in itself, increase of knowledge is its immediate goal. Man has been accumulating knowledge through observation and experience during the whole period of human history, as a by product, so to speak, of his struggle to live and better his condition; but research builds up knowledge in a different way.

Scientific research ordinarily implies a methodized procedure and uses as its most effective tool rigorously controlled experiment. Forest research is now organized and systematized; and some would draw a line of demarcation between what is fully entitled to be called forest research because it employs the method of controlled experiment and what is merely the accumulation of knowledge through observation of what goes on in the ordinary sequence of uncontrolled natural events.

Historically, such a distinction does not fit. Forest research of the present day has been built up from the early observational study of the American forest—of its composition, behavior, relationships, services, and possible products and of the effects upon it of cultural methods or of lumbering, grazing, fire, and other forms of human or natural interference—together with inquiries, chiefly of a statistical character, relating to forest economics, and with the beginnings of laboratory experimental work on wood as a material.

In the initiation of these investigations and the opening up of the field for forest research the States took an active part. An example is the work carried on in Ohio for a few years by the forestry department created in 1885 and centering at the State university. Still more striking is the investigative program formulated and pursued for a time by the California Forestry Department dating from the same year; this included the setting up of two forest experiment stations—the first ever started in the United States. Kansas set up two experimental tree-planting stations. A number of States assigned to their geological surveys investigations of their forest resources. The work of botanists connected with State institutions also calls for recognition. And when, after the turn of the century, State foresters began to be appointed, their task was to a considerable extent investigational. Indeed, in those days every cutting or planting operation carried out in accordance with a forester's prescription partook of the nature of an experiment; and the chief means by which a basis was created for American silviculture was woods observation by the first generation of trained foresters.

While the investigational quality, and indeed purpose, of the first applications of technical forestry by both Federal and State foresters justify classing much of this early work as forest research in a broad sense, time has wrought a great change. Silvicultural practices, it must be admitted, still often lack a firm basis of certainty as to what will be the outcome of this or that course, and management policies must too much grope their way, with opportunism taking the place of long-range planning; but the professional forester engaged in managing a forest property is essentially a practitioner, not an explorer of the unknown. On the other hand, forest research has become organized and implemented for careful, systematic work; its pioneer stage has been left behind. It is under the necessity of covering a field of enormous range and complexity, demanding the work of specialists in many different fields of scientific knowledge. It has turned away in the main from broad, superficial investigations yielding immediately serviceable approximations, to engage in much narrower but deeper studies designed to obtain precise information on details. This is true even though the advance in this direction has been less than would be desirable. There remains too large an unfilled need for approximate information, and the resources available in trained men and money are still too small, to permit attention to the more fundamental matters proportionate to their importance.

PRESENT SCOPE OF FOREST RESEARCH

The breadth and diversity of the whole field, as now covered with very varying degress of intensiveness, may be briefly indicated. To facilitate the growing of commercial timber crops, research seeks the information basic to all silvicultural practices. This includes methods of cutting the mature stands so as to insure satisfactory reproduction of the kinds of trees wanted for the next crop; forest planting; determination of the rates of growth of stands; and methods of weeding and thinning immature stands to produce the most rapid growth and the best products. The behavior, effects, and statistics of forest fires are studied to obtain a better basis for devising protective measures. For the same purpose investigations of forest insects and diseases are carried on.

In the field of forest products utilization, research seeks new uses for wood, extends present uses to other species, and by deep-going study of the physical, chemical, and mechanical structure of wood gains fundamental knowledge for application in all kinds of wood processing, adaptation, and manufacture. The life and food habits of forest animals and birds are studied to learn how the best balance of game and other wild life in the forest may be maintained. The knowledge necessary for the best use of forest ranges in proper coordination with the use of the timber and other resources is sought through range investigations. Forest influences present an important field of inquiry. In economics, information indispensable to the progress of forestry in all fields is gained on such diverse matters as the extent and character of the country's forest resources, the ratio between forest depletion and rate of growth, our probable future timber requirements, the trends in forest products utilization, the taxation of timberlands, timber insurance, and the financial aspects of timberland management. These are the major divisions of forest research. They are commonly referred to as forest management, range management, forest protection against fire, forest entomology, forest pathology, forest biology, forest influences, forest products utilization, and forest economics.

RESPECTIVE FIELDS OF THE FEDERAL GOVERNMENT AND THE STATES

The organization of forest research along comprehensive lines, permitting a methodical attack in force on the forest problem as a whole, has taken place only in very recent years. This form of attack makes desirable a coordination of all available research agencies. The Federal Government is doing far more in forest research than any other single agency—a natural result of the fact that it is much the largest owner of forest land in the country and is applying forest management more extensively than all other owners put together; not to mention other reasons for Federal forest research. This position carries with it at once an opportunity and an obligation to plan for and endeavor to bring about coordination.

The Federal coordinating function is not new. To provide centralized leadership of the early forestry movement was the outstanding function of the Federal Division of Forestry in its days of small beginnings. In those days the share taken by the States was relatively large, partly through the cooperation of botanists attached to State institutions of learning. With the rapid growth of Federal forestry after the turn of the century, however, the tendency was for a time to leave to the Federal Forest Service the research necessary for building up the practice of forestry. This trend was strengthend by the demands made upon the State organizations and funds as they entered upon administrative activities of organized fire protection and in some cases of forest land management. On the other hand, as schools of forestry were established new potential agencies for forest research in the States were created. In the aggregate, the organizations and institutions which can participate in a correlated program make up a rather imposing list. Obviously, the greater the number of agencies the more desirable becomes coordination, with each agency taking the kind of work that it is best fitted to engage in.

The following summary of forest research projects active in 1930 in New England and New York illustrates how State and Federal agencies may coordinate their work with each other and with that of private organizations. (Table 3.)

TABLE 3.—*Distribution of research projects carried on in New England and New York in 1932, among the several agencies conducting them*

Agency responsible	Number of projects by character of work								
	Forest management, mensuration, dendrology, and ecology	Forestation (seed studies, nursery, and planting)	Forest protection	Forest products and utilization	Forest economics	Fish and game	Recreation	Total	Percent by agencies
Forest schools	68	24	4	7		4		107	37
Agricultural colleges and experiment stations	17	2	6	2	1			28	10
Other colleges and universities	9	1	11	3				24	9
State forestry departments	5	5	5	4	2			21	7
U.S. Forest Service	17	1	3	4				25	9
U.S. Bureaus of Plant Industry and Entomology			12					12	4
Botanic gardens and scientific institutions	2	2	3					7	2
Associations and committees		1			3		2	6	2
Companies	29	15	7	1				52	18
Individuals	6							6	2
Total	153	51	51	21	6	4	2	288	100
Percent by classes	53	18	18	7	2	1	1	100	

Of the 288 investigative projects, 37 percent were being conducted by the forest schools, 10 percent by agricultural colleges and experiment stations, 9 percent by other colleges and universities, and 7 percent by State forestry departments. Many of the investigations by the forest schools and presumably some also by other colleges and universities are privately endowed, so that the amount of strictly State-supported school research is obscured. Over 63 percent of the work by the forest schools is in forest management or closely related subjects. The greater part of the investigations of the State forestry departments is nearly equally divided between forest management, nursery and planting, forest protection, and forest-products utilization. The research in forest economics, fish and game, and recreation is far below that in the other subjects, but newly awakened interest will probably demand increasing attention to these subjects in future.

The research activities of the State forestry departments at the present time are in the main the outgrowth of the requirements of their administrative work. The activities have been undertaken, as a rule, because of the need to find answers to concrete practical and localized problems. Most of the resulting projects have been small scale, limited in scope, and very specific in purpose. In many States these essentially ad hoc minor investigations have been about all that the funds available for the entire work of the departments make possible. Examples are investigations relating to forest-tree nursery and planting practices, the development and improvement of forest fire fighting equipment, fact-finding surveys of the wood-using industries, studies of forest growth, and studies of forest-tree insects and diseases. These are all of direct and important value to the organizations. The only State forestry department in which research has advanced far enough to attain what may be called a major status is that of Pennsylvania, though Maine gives major status to the study of forest insects.

As is pointed out in the section Research in the United States Forest Service, a Study in Objectives, a line of division of responsibility between State and Federal functions is recognized in the research objectives of the Federal Government. Federal research deals with national or regional problems, and with local problems only in so far as their solution is necessary to the proper administration of the National forests. The responsibility for research on forestry problems of primary importance to individual States should rest in the main, it is believed, with the States themselves, most of which by now have forestry departments and many of which have State-supported schools of forestry and other research agencies. On the other hand, it is necessary to take into account also what the States are equipped to do and likely to do.

Insofar as the State forestry departments are concerned, the scope and character of their research activities are bound to be governed by the nature of their jobs as well as by the extent of their resources. Where State forestry departments are charged with important responsibilities of forest land administration for timber growing, the need for silvicultural research to provide a sound basis for forest management must sooner or later come to the fore, as it has with the Federal Forest Service in connection with the administration of the National forests. Hitherto, however, only a few States have entered upon policies of forest ownership and management on a substantial scale. The effort has been mainly directed toward encouraging and aiding private forestry. Most of the work of fire protection—the major activity of the State organizations as a whole at the present time—has this as its objective. Similarly, most of the States which maintain forest tree nurseries to produce planting stock do so primarily to aid private owners in reforestation. Assistance to private owners through information and advice on forestry practices and methods is another duty of most of the State forestry departments, though in considerably varying degree. Here, obviously, the results of silvicultural research are needed, and will be more and more needed as practices of forestry by private owners become intensive. The need of forest research for this purpose is of the same general kind as the need for agricultural research on behalf of agriculture.

Obviously, the outstanding immediate need of most States has been for more light on matters directly affecting their operations in connection with fire control and the production and planting of nursery stock. Planting methods are important not only in connection with planting operations on State forests, in those States having them, but also for guiding private owners to whom the State supplies the stock grown in its nurseries—if the field planting is a failure the work of the State in producing the stock has gone for naught. It has been to meet immediate needs of these kinds that most of the ad hoc minor investigative projects already referred to have been undertaken. But whether or not the States are likely in the near future to enlarge materially their administrative field through building up State forests (which there is reason to expect), it will be necessary to obtain in some way the basic knowledge required to advance the practice of forestry. This raises the question of the research facilities available, actually or potentially, for that part of the investigative work which will not be taken care of through the Federal agency.

STATE FOREST RESEARCH FACILITIES

Facilities for State forest research are afforded (1) by the State forestry departments, (2) by the universities and colleges in which technical forestry is taught, and (3) by State agricultural experiment stations.

Facilities of the State forestry departments.—State forestry departments vary greatly in age, available funds, and range of activities. Some are still in a preliminary stage of organization, struggling with inadequate resources to meet difficult and critical problems, of which the protection of the forests from the devastating effects of fire is sufficient, alone, to absorb much more than the meager funds granted them. Other States with older and more strongly developed departments have advanced further in research, the beneficial effects of which are becoming apparent. Pennsylvania and Michigan have gone so far as to establish forest research centers and experimental stations, while others have developed forest nursery research and test arboreta, or have made valuable contributions through the study of tree species or forest types within their boundaries.

The Pennsylvania Forest Research Institute at Mont Alto is outstanding as a forest research agency which is an integral part of the State forestry department and is provided as a part of its equipment for performing its practical duties. This institute was dedicated to forest research on June 5, 1930, to bring about the betterment of forest practices on all types of forest land in Pennsylvania. The studies to be undertaken cover a wide field and embrace both those termed fundamental and those classed as administrative. The staff of the institute is made up of five to seven technical men.

Somewhat similar in its field of work is the Cloquet Forest Research Station, located at Cloquet, Minn.; but this station is not maintained by the State forestry department but is a part of the Agricultural Experiment Station of the University of Minnesota. It was established in 1909 and is devoted to a study of the problems of the northern Minnesota woods.

Another station worth noting is the Michigan Forest Fire Experiment Station at Roscommon, Mich. It was organized in 1930 and is a cooperative enterprise of the Michigan Department of Conservation and the Lake States Forest Experiment Station of the United States Forest Service. Both the State and the Federal Government are represented on the station staff, and the various investigations under way are divided between them by mutual agreement. As its name indicates, the station was established to make forest-fire investigations. This includes a variety of subjects such as fire weather studies, firebreak construction, fire damage, slash disposal, and the development of fire-fighting equipment.

The needs of the State forestry departments for more knowledge will call for an increase of research facilities such as these stations afford. The Pennsylvania Forest Research Institute is an example of what might easily be done by a number of the more wealthy States, at least, to enable their forestry departments to work out their more fundamental problems. On the other hand, the Minnesota station affords an example of an alternative course which a good many States will doubtless prefer to take. Instead of setting up special provisions for the conduct of major research projects, arrangements may be made to have the work of this kind assumed by the forest schools and agricultural experiment stations. Some States are now pursuing this course.

Research facilities at State forest schools.—A considerable amount of research in the aggregate is conducted by divisions, departments, and schools of forestry attached to the State universities or colleges of 19 States. The amount varies greatly. Most of the forest schools have faculties of from 2 to 4 professors only, who usually have little time for research. Hence the larger part is done by relatively few schools of forestry, at which special provision of one kind or another is made for the purpose. In general, the research which is done by the schools equipped for it is more intensive and less limited in point of applicability than that performed by the State forestry departments.

Not all of the forest schools, of course, are connected with the State-supported colleges and universities. Some of the privately endowed universities, notably Harvard, Yale, and Duke, occupy outstanding positions in the list of institutions equipped to share in the general forest research program, and need to be included without distinction from the State-supported institutions in appraising the available facilities for the work in the States.

Limitations upon the resources of the forest schools affect the amount rather than the kind of research. Their field is much broader than that of most of the State forestry departments—so broad that each school must select from it. The resulting diversity of programs is brought out in the section, Privately Supported and Quasi-public Forest Research. The schools have the opportunity, not generally possessed by the State departments, for doing research of an advanced and intensive character. Nor are they as limited as are the State departments to work relating to their own State.

The character and scope of this work has been a result partly of the recognized urgency for basic knowledge in forestry, partly of the affiliation of the forestry courses with other university departments having definite research responsibilities, and partly of the opportunity and duty of the schools to turn out graduates especially trained for research, to recruit the personnel of the schools themselves and of other established forest research agencies. Accordingly various schools have adopted definite policies of research. At the University of California,[3] for example, each member of the forest school staff is required to devote half of each college year to research, and during this period he is relieved of all teaching duties. Problems of the range, forest mensuration, logging, milling, forest influences, and silviculture have been the principal subjects of research. At the New York State College of Forestry the faculty members have been allotted liberal time for research, and especially significant work has been done in wood technology, wood chemistry, wood utilization (particularly as related to the problems of pulp and paper), forest entomology, and forest pathology. The school maintains an institute of research in wild life, the Roosevelt Wild Life Experiment Station. At a number of other schools—for example, Cornell, Idaho, Michigan, and Minnesota Universities, and Pennsylvania State College—research is expected of all staff members. At Cornell, Idaho, Pennsylvania State, and Purdue men are employed who give their full time to investigative activities. At the Iowa and Michigan State Colleges and the universities of New Hampshire, Utah, Montana, and Washington one or more instructors are devoting considerable time to research. Usually the research is done within the confines of the State, and hence is concerned to a considerable extent with problems important within the individual States, or with local aspects of general problems. Some of it, however, is on subjects broadly fundamental, the results of which are of high regional or even national value. Thus while the forest schools are a most effective research aid to the State forestry departments in advancing the sound management and utilization of the State forest resources, their efforts can be, and generally are, effectively coordinated with the Federal forest research system through the regional forest experiment stations and the Forest Products Laboratory.

FOREST RESEARCH BY STATE AGRICULTURAL EXPERIMENT STATIONS

Forest research by the State agricultural experiment stations, under the terms of the Hatch, Adams, and Purnell Acts, is interpreted as relating only to agricultural aspects of forestry. Since farm woods comprise about 25 percent of the entire forest area of the country (from 30 to 50 percent in the Southern, Middle Atlantic, and Central States) and since the value of products cut and sold from farm woods ranks high among all farm products in a number of States, a large field for forest research is presented for the agricultural experiment stations, and for cooperation between these stations and the forest schools, in the States having the latter. In the West the agricultural experiment stations are conducting a very considerable amount of research in the fields of range management, ecology, and economics which coordinates with or is closely related to the forest-range investigations of the Federal forest experiment stations. At least 26 States are carrying on some work that has to do with forestry or with the problems of range management.

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[3] Cf. Forest Education, by Henry S. Graves and Cedric H. Guise. Yale University Press. 1932. P 288.

EXPENDITURES FOR STATE FOREST RESEARCH

Anything like an exact statement of the present expenditures for State forest research is impossible. In the section State Aid to Private Owners and Local Political Units an incomplete showing for the fiscal year 1932 reached a total of not quite $176,000. This showing was based partly on specific data and partly on estimates. The latest statistics of annual expenditures by the State forestry departments—variously reported for the years 1931 and 1932—show an aggregate expense of $97,855 for research. It seems not unreasonable to estimate the forest research expenditures of the forestry and other departments of State universities and agricultural colleges at $165,000. This, of course, does not include the expenditures by privately endowed institutions, discussed in the section Privately Supported and Quasi-Public Forest Research.

The data presented in the section State Aid to Private Owners and Local Political Units showed only one expenditure by an agricultural experiment station, amounting to $8,000. The listed projects of the stations, however, evidence a rather widespread activity in various lines of forest research. Collectively, the agricultural experiment stations appear to have spent on research projects in forestry about $14,000 of Federal funds received under the provisions of the Hatch, Adams, and Purnell Laws. Including this $14,000 the experiment stations probably devoted to research projects that fall within the field of forestry or correlate with Federal forestry investigations about $55,000, exclusive of $75,000 for range research in the West.

In addition the States contribute to various activities that involve research or relate closely to it. Expenditures totaling some $50,500 in 1932 by the Pacific Coast and Lake States for economic survey work on forest land fall in this class. The amounts spent in the different sections of the United States are given in the section on State aid referred to above.

The aggregate expenditure by all State agencies is thus somewhere in the neighborhood of $443,000, of which about $14,000 is supplied by Federal grants.

Divided as these various classes of research expenditure are among many States, the sums are inconsequential and entirely disproportionate to the size and importance of the forest problems confronted in most cases. The funds allocated to research by the State forestry or conservation departments, including those for economic forest land surveys, amount to only about 2 percent of the aggregate appropriations to these departments.

CONCLUSIONS

State forest research should in the main complement that of the Federal Government though dealing primarily with problems of special importance to individual States. This is particularly true for the State forestry departments, few of which are equipped to engage in research on a major scale. Their investigations are at present limited for the most part to the solution of exigency problems arising in the course of other activities, but their needs will necessitate the provision of increased facilities, either of their own or provided by other State research agencies.

The forest schools of the State agricultural colleges and State universities are in a position to meet both State and Federal needs for information obtained through research. Their field is divided between problems local to the States in which they are situated and problems of basic value to all branches of forestry, outside of as well as in the State.

In general, an opportunity for most effective cooperation in research is provided by the Federal forest experiment stations and Forest Products Laboratory, the State forestry departments, the State forest schools, and the State agricultural experiment stations, each within its own field coordinating systematically in the task of increasing the knowledge needed for forest management.

The systematic cooperation of these agencies and the Federal Government, coupled with the large amount of technical research which cannot be escaped by private industries, is essential if the expansive field presented to forest research is to be covered amply and economically. The Federal Government carries the responsibility for research on national and regional problems, and on local problems affecting national-forest administration. Many of the agricultural experiment stations have facilities for at least some classes of forest research.

The State forest schools carry the dual responsibility of aiding both the national and the State services. For the national service, in addition to supplying the trained personnel needed, they are in a position to increase very greatly, from local sources, the fund of knowledge made available by other research agencies, and especially to undertake research along lines not otherwise provided for. They can assist the State departments materially by concrete research on State problems for which the departments may not have time or facilities. In both respects the research function of the schools is unquestionable and outstanding. They should be a much stronger link in the chain of forest research activities than they now are.

The funds at present expended by the States on forest research are relatively meager. The proportion of their total allotments now spent by the State forest departments on research and forest land surveys (amounting to about 2 percent) should be greatly increased through additional appropriations to permit of an expansion of research activities. An average of 10 percent of the appropriations to the forestry departments of State universities and colleges might reasonably be expected to be devoted to research; and the increasing importance of farm woods justifies far greater research effort by the agricultural experiment stations than is now being given.

AID IN REFORESTATION

The outstanding facts with respect to State efforts in reforestation are brought out under the discussion of Federal Financial and Other Direct Aid to the States. Thirty-eight States, Puerto Rico, and Hawaii are now growing forest trees in their own nurseries or contracting to have them grown, selling a part of them to the public in accordance with their own State laws, and planting the remainder on their State forests. In these 38 States 76,631,000 forest trees, sufficient to plant from 75,000 to 80,000 acres of land, were grown for these purposes during the calendar year 1930.

The funds appropriated by the States for reforestation activities for the year 1932 total over $1,000,000. The greatest development in this activity occurs in the Middle Atlantic States, the Lake States, the New England States, and some parts of the Central States. In the regions where public interest in forestry is general private landowners have taken kindly to the idea of planting worn-out fields and pastures. Forest planting was one conception of forestry that they could readily grasp. Sentiment, more than economics, has been responsible for a big part of the planting by individual land owners. Water companies on the other hand have planted rather extensively for the protection of watersheds, and States and towns have freely planted on State forests and on town forests. A temporary peak in planting operations by private owners seems to have been reached. Stock from State nurseries is not moving to private owners quite so freely as formerly. The water company lands are pretty well planted up; farmers and other private landowners are affected by the depression.

Of all the States, New York has today the most ambitious reforestation program. It entails the buying over a period of years of 1 million acres of land for State forests, and the planting of such portion of that total as is not satisfactorily stocked with forest trees. Marginal and submarginal farm lands will make up the bulk of the area to be purchased under this program. Most of this will have to be reforested. Approximately 1 billion trees will need to be grown in the State nurseries during the next 10 or 11 years to meet the needs of the State alone in this reforestation program.

The other States will doubtless continue to produce enough trees in their nurseries to meet the public demand and to meet their own needs for planting on State forests. Available figures indicate that to the end of the year 1931, 271,811 acres of land had been planted by the States on State forests.

Insofar as the State organizations are concerned, they have developed the personnel and forest nursery facilities sufficient to take care of any probable demand for forest planting stock. They can easily expand their nurseries if necessary. Their policies are pretty much the same in respect to distribution of trees from State nurseries. Trees are sold at cost of production to the landowner, for forest planting only. Under their laws some States furnish political units such as towns, counties, and boroughs with free trees for planting in the community-owned forests. The States do not raise ornamental stock for distribution to the public.

Comprehensive efforts to stimulate State-wide programs of planting all land that appears better suited to forest production than other purposes have not been made. The nearest approach to it has been in Pennsylvania and New York. Both of these States have developed nurseries that have turned out millions of trees each year, which have either been sold to private landowners or planted on publicly owned lands. Still there has been no definite goal set up, no actual survey of the situation to find out how much land needed planting, nor a policy, comprehensive program, and means provided to bring these lands into forest productivity.

There is no exact knowledge of the amount of land that needs planting. Many areas which appear to need planting today may reclothe themselves with trees in 10 years. Areas which do not need it today may become hopelessly devastated by fire next year or the year following. There are, however, in some States vast areas of land that by no stretch of the imagination will come back into forest growth without planting and which appear hopeless for any use in a large way except the production of timber. It seems that if such lands are to be made productive at all, if they are worth saving, the State must boldly take the initiative in their reclamation. This may be by liberally subsidizing the private owners or by acquiring and planting the lands itself. Michigan has been acquiring and planting such lands, but comparatively speaking only at a snail's pace; New York has resolutely decided to acquire and is engaged in the program of acquiring marginal and submarginal farm land, which is being planted. There are vast areas in the Southern States of cut-over and burned-over land that apparently will come back to productivity only if planted, and large areas of the same type of land are developing in some far western States. Will the States meet this problem—are they financially able to do so? It appears very doubtful.

The question naturally arises as to whether all such land should be planted, whether it will pay. No one can answer that question. Viewed in the light of present timber values and the probable growth of timber, it seems that planting cannot be justified on much of the poorer and relatively inaccessible lands if the first crop of timber only is considered. The mere clothing of these lands with trees, however, might have tremendous significance in the future. A resource would be there that if correctly managed could be made self-perpetuating and the means of sustaining local industries and communities. To pass up this undertaking on the ground that it is uneconomic is the easy way out of a real problem; it may not prove to be the best way.

There are possibilities of developments in nursery practice, in planting machinery, and in field technique that may make the planting job much cheaper than it has been. These would make the task ahead of the States much more simple; for after all the extent to which the States themselves are likely to engage in or subsidize forest planting is going to be governed by its cost.

AID THROUGH SPECIAL TAXATION MEASURES

The subject of forest taxation is too intricate to be dealt with comprehensively in the present section of this report. All that is necessary here is to indicate very briefly its place in the development and general scheme of State policies of forestry. While an appraisal of the potentialities of changed methods of taxing forest properties as a means of bringing about more private forestry is essential to a size-up of the task which public agencies will have to assume, and while taxation cannot be omitted from an outline of the stage of progress which the States have attained in their forestry effort, it is not possible to discuss in detail here the efficacy of tax laws as a means of promoting forestry or the practical workings and comparative merits of the various laws hitherto passed.

The following historical summary of the legislation is taken from Progress Report No. 16 of the Forest Taxation Inquiry of the Forest Service, issued January 1, 1932.

> Forest tax legislation in the course of its development in America has passed through two fairly well-defined stages. At the outset tax relief was used as a means of interesting landowners in tree culture, evidently without any very clear program based on fundamental principles of forestry or of taxation. The movement at this stage started with a law passed by the territory of Nebraska

in 1861 granting exemption to landowners who would plant and care for stands of forest trees fulfilling certain conditions. Between then and 1886, similar laws were passed by nine other Prairie and Western States, namely, Wisconsin and Iowa (1868), Dakota, then a territory (1869), Idaho (1875), Washington and Wyoming (1877), Colorado (1881), New Mexico (1882), and Utah (1886). Before this wave of exemption laws had gotten well under way, Kansas started another movement of similar import by a law enacted in 1868 offering bounties for tree planting, which up to 1890 was followed by three of the States which had already enacted exemption laws and four others, namely, Missouri (1870), Minnesota (1871), Nevada (1873), Illinois (1874), Nebraska (1879), territory of Dakota (1885), and Wyoming (1890). Upon being admitted to statehood (1890) North Dakota and South Dakota reenacted the territorial law of 1885. and later enacted bounty laws, in 1905 and 1909 respectively.

Almost simultaneously with this western movement, the report goes on to point out, tax concessions to promote tree planting appeared in the East, beginning with Maine's exemption law of 1872.

By 1878 three other New England States, namely, Massachusetts, Connecticut, and Rhode Island had passed similar laws. Vermont later (1904) passed such a law, followed by Alabama (1907) and New York (1912). Pennsylvania (1887) and New Hampshire (1903) adopted the rebate, * * *. Massachusetts (1908) and New Hampshire (1915) granted exemption to those who would leave the entire management of their lands to the State for a period of years. Indiana (1899) adopted the plan of reducing the taxable valuation to the sum of $1 an acre which plan was also adopted by Iowa (1906) and Louisiana (1910). Hawaii (1892 and 1903) enacted forest exemption laws which were designed to prevent overgrazing and protect the watersheds, and which have been widely applied.

In general, the exemption, bounty, and rebate laws gradually demonstrated their inability to accomplish any substantial results. At the same time knowledge of the broader aspects of forestry and its economic implications was increasing. Increasing attention was being given to the relation of taxation to the practice of forestry. Out of these conditions arose the second stage of forest tax legislation, in which the yield tax occupies the center of the picture. Beginning with the Michigan farm wood lot act in 1911, 17 States have enacted tax legislation based on the yield-tax principle, the others being New York (1912), Vermont, Connecticut, and Pennsylvania (1913), Massachusetts (1914), Maine (1921), Alabama (1923), Mississippi (1924),[4] Ohio (1925), Louisiana and Kentucky (1926), Minnesota and Wisconsin (1927), Idaho and Oregon (1929), and Washington (1931). Michigan (in 1925) enacted a second yield tax law, which was applicable to commercial forests.

During this same period also much legislation of the same type as that passed in the earlier period was enacted. New York in the same year that it passed its yield tax law (1912) enacted provisions granting several degrees of exemption of land and timber value for 30 and 35 year periods. Idaho (1917) passed a tax-exemption law for planted lands. Louisiana (1920, 1922, and 1924) enacted a series of changes in its original exemption law culminating in a pronounced curtailment of the exemption privilege in 1922, followed by moderate liberalization in 1924. Indiana (1921) reenacted and amplified its exemption law of 1899, which in the meantime had been declared unconstitutional. New Hampshire (1923) copied the 1922 Massachusetts law almost verbatim, save that constitutional restrictions prevented the adoption of the yield tax as such. So, as an alternative, the timber when cut was made subject to the ordinary personal property tax of that year based on its value after felling instead of its stumpage value. This virtually converted the Massachusetts type of yield-tax law into a growing timber exemption law, with full ad valorem taxation of the bare land value. Vermont (1923), likewise dissatisfied with the way its yield-tax law was working, without repealing the old law, enacted a new law which provided for the exemption of growing timber and the full-value taxation of the land, thus duplicating in part the New Hampshire law, save that the exemption was limited to a period of 30 years. Puerto Rico (1925) enacted a law reducing the taxable valuation on planted lands to $1 per acre for a limited period, but a later (1930) law provided for complete exemption for both planted and natural-growth forests for an unlimited period. California (1926) adopted a constitutional amendment exempting all immature forest trees from the property tax. Connecticut enacted an exemption law with certain novel features in 1929. Delaware (1931) provided exemption for a limited time for properties containing small trees.

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[4] This law was repealed in 1932, subsequent to the issue of the report from which the quotation is taken.

In some of the more recent yield-tax laws, certain novel features have been introduced. Thus the Michigan law of 1925, the Minnesota and Wisconsin laws of 1927, and the Oregon law of 1929 give up entirely the ad valorem property tax on land and trees and substitute a specific tax at a flat rate per acre. Another novelty is a provision requiring a contribution from the State to the local subdivisions, in consideration of the loss of local revenue occasioned by modification of the property tax. Such provision is contained in the laws of Pennsylvania (1913), Michigan (1925), and Wisconsin (1927).

The constitutional amendment of California (1926) and the laws of Oregon (1929) and Washington (1931) represent an important innovation in forest-tax legislation, in that the classification of lands receiving special treatment is not dependent upon application by the owner. In Oregon and Washington the law requires the State administrative officials to take the initiative in bringing about classification. California goes still further toward universality by exempting from the property tax all immature forest trees without requiring action by either the owner or any public official to complete classification.

Recent legislation in Kentucky and Virginia (1930), which is designed to relieve the tax burden on forest property, is of an entirely different type from that mentioned heretofore. Both States provide for the leasing of private forest land to the State. In Kentucky the compensation to the owner is in the form of rental not to exceed the amount of annual taxes, and in Virginia the compensation is the deferment of the annual taxes for not longer than 40 years.

Many of the laws mentioned in the preceding paragraphs have been repealed and replaced by other forest-tax legislation of similar or of dissimilar type. The States of New Mexico, Utah, Kansas, Missouri, Nevada, and Nebraska have repealed the forest-tax legislation which has been mentioned here, and now these States have no special forest-tax laws on their statute books.

The progress report shows that up to July 1, 1931, a total of 1,370,791 acres was classified under the provisions of the laws discussed, distributed among 17 States, in the amounts which appear in the acreage column below:

State:	*Acreage*
Alabama	50, 494
Connecticut	6, 846
Idaho	53, 371
Indiana	60, 000
Iowa	43, 105
Louisiana	375, 292
Maine	20, 000
Massachusetts	25, 000
Michigan	74, 285
New Hampshire	8, 456
State—Continued.	
New York	2, 902
Ohio	36, 803
Oregon	256, 216
Pennsylvania	42, 186
Rhode Island	88
Vermont	37, 472
Wisconsin	278, 275
Total	1, 370, 791

State laws have apparently been the means of affording tax relief to about 1,400,000 acres of forest land, or less than three tenths of 1 percent of the total area of forest land in private ownership in the United States. How much land is now coming under these laws yearly is unknown. Except in Louisiana, Oregon, Washington, and Wisconsin the amount is probably small. In Oregon and Washington the law requires classification of lands of certain well-defined character by the State officials, unless the owner interposes objection. This will eventually bring a large acreage under the operation of the law, provided the land remains in private ownership. In Wisconsin a liberal interpretation of the law is inducing private owners to take advantage of it rather extensively.

AID THROUGH FOREST PROTECTION

PROTECTION AGAINST FIRE

Organized and successful protection of forests against fire is a sine qua non of timber growing and forest perpetuation. It is often essential for maintaining a timber cover of any kind; it is always and doubly essential to planned forest management. So long as the danger that forest fires will sweep unchecked across wide stretches of country looms large, permanent investments in timber production are almost sure to come to grief, at least for large landowners. Lack of protection, rather than lumbering, has created out of former timber lands most of our near hopelessly bankrupt no-man's land.

Lumbering may work havoc with the forest. It may leave the cut-over area in a condition from which its restoration to satisfactory productiveness will be too slow and costly a process to interest the private owner. By and large, however, the logging operations themselves do not so impair or destroy the fertility of the soil that the capacity to produce further crops of valuable timber is lost for many years. Nor do logging operations of themselves ordinarily lay the land bare of all forest growth.

Protection a means of lessening land abandonment.—Even where land seems to have been denuded, with protection some kind of a forest cover will as a rule gradually creep back. The return may be very slow, and the new stand may be of very inferior composition and quality, but from one source or another nature finds means to begin a regenerating process. Conversely, where repeated fires are allowed to run uncontrolled, a process of forest degeneration is at work even though the forest itself is left in place. The soil is impoverished, the vigor, rate of growth, and density of the stand are decreased, usually its composition is changed for the worse, and the quality of the timber is impaired. Adequate protection not only arrests the enlargement of the denuded area and permits the establishment on cutover lands of a new crop of timber but also gives many of the old burns a chance to regenerate gradually and stops the decline in quality and value of already established forests. This tends to keep the land in private ownership.

Very few States wish to enter on policies of extensive forest ownership and administration, if it can be avoided. Relatively few are prepared to meet the immediate costs. Whether or not State-operated enterprises of forest management will eventually become sources of net income, most States are not easily able to make the outlay necessary to acquire, block up, put under administration, and develop to an income-producing stage large tracts of lands now in private ownership; nor are they desirous of going into the business of timber growing unnecessarily. Outside of a small number of States in the Northeast, and another small number of western States which are holding large areas of granted forest lands, most policies of retention or acquisition have had in view primarily what may be called park uses—that is, provision of outdoor recreational opportunities, protection of wild life, and the safeguarding of scenic resources—rather than enterprises in growing and harvesting timber crops, except where the breakdown of private ownership is forcing forest land upon the public on a large scale.

It is at least highly probable that tax reversion would be still more widespread had not organized State systems of protection operated to hold in check forest deterioration and forest destruction, and thus give the private owner more incentive to hold on. A continued drift of forest land from private into compulsory public ownership is likely to include not only great areas of land virtually denuded of valuable timber growth but also much land on which the forest has degenerated to a point which makes holding it unprofitable. The more effectively forest fires are kept out, the smaller will be the dimensions of the problem of public forest management forced on the States; the more generally fires are allowed to degrade or remove the forest growth, the greater will be the amount of land abandoned and the public expenditures necessary to build up again to a productive condition the depleted resource.

Few people realize the magnitude of the scale on which forest degradation has taken place. To the uncritical observer the great amount of land still covered with tree growth is deceiving. The numerous and often large wooded tracts throughout the East seem to contradict the idea of waning forests. It is not the final disappearance of the forest but its transformation into a state in which the production of high-grade timber is no longer taking place, or is taking place only meagerly, that constitutes the major threat to the future.

Stopping forest fires will not of itself bring the process of forest degradation to an end—that can come only through skillful management in place of a mere wild-land holding with removal from time to time of what unaided nature happens to produce of economic value. Private owners will voluntarily take up forest management when, where, and if they find that it will afford them a greater profit than letting the forest take care of itself. Through the advancing exploitation of what is left of the virgin forests and the continuing depletion of the second-growth stands, the prospects for profitable timber growing are being steadily improved. On the other hand, through forest deterioration the possibilities are being markedly lessened. The greater the deterioration, the heavier will be the cost and the longer will be the wait before normal productivity can be built up again. It is to the interest of the States to hold back, so far as possible, the drift of unwanted forest land into public ownership through tax forfeiture if there is a reasonable hope that the private owner will in time put the land under management for timber growing. It is also to the interest of the State that, to whatever extent reversion does take place, the burden of restoring the land to a condition of productivity shall be as light as possible. Maintaining adequate systems of protection against forest fires serves both these ends.

In some regions adequate protection is of crucial importance as an encouragement to selective logging in place of clean cutting. An owner who would like to leave part of the merchantable stand for further growth and for seeding in the openings must have reasonable assurance that the residue of the crop will not be burned up before he will be ready to return for it 10, 20, or 30 years hence. Adequate protection also serves to stabilize recreational, wild life, and water resource values. From the standpoint both of private and of public values, its effect is tonic, with the benefit most pronounced where the susceptibility of the forests to fire damage and the exposure to fires are greatest.

Protection the major activity of State forestry departments.—In a considerable number of States, forestry departments were first brought into existence to provide for organized systems of protection against forest fires. This is particularly true in the South and the far West. In some other States great fire disasters that caused terrible losses of property and life so aroused public sentiment as to cause very substantial increases of appropriations and authority. In nearly all States the maintenance of the protective system is the most outstanding form of forestry activity. The problems of protection are still for most States urgent, and in many cases will probably continue for years to demand major attention. While protection is not as yet generally adequate, it is the greatest accomplishment of State forestry. More constructive effort has been put into it and more money spent on it than on any other form of forest activity. It has demanded the services of both administrators and investigators. The development of its technique has been one of the most notable achievements of forestry in the United States.

While State forest protection has been immensely stimulated by the Federal aid offered under the Weeks law of 1911 and the Clarke-McNary law of 1924, progress in efficiency has not come about merely because there was more money to spend. It has been no less due to the ability and determination of the State forestry officers. A number have built up forest fire organizations that use practically all of the most up-to-date methods; others have made substantial progress even under very discouraging conditions.

Organization and methods.—Thirty years ago forest fires were rarely fought at all except as they endangered other property. Then it was a case of neighbor help neighbor when a fire became an obvious menace; and the equipment and methods used were of the crudest. A forked stick for clearing a line through the leaves, a piece of brush or a wet gunny sack to beat down the blaze, and garden shovels, hoes, and rakes were the common implements. There was no order, no planned organization, no conception of the strategy and methods necessary in fighting big fires, no knowledge of their behavior, no system of detection and speedy alarm, no preparation beforehand for swift attack, and only the most elementary beginnings of fire prevention.

All of this has changed. State and Federal agencies working together have evolved organizations, equipment, and methods that work with precision and dispatch and are fairly well standardized throughout the country. Observation stations of steel or wood placed high enough to command an extensive view, often on towers rising more than 100 feet from the ground, now dot much of the wooded area of the country. When the systems are completed these stations will afford a coordinated and interlocking oversight of entire regions from strategic points 15 to 20 miles apart on an average—though the distances vary greatly with the topography and other factors that determine the range of visibility. Already the stations embraced in the State protective systems number more than 800. In some localities they dovetail with the detection systems maintained by the Federal Government on the national forests, now equipped with nearly 1,400 lookout stations.

From the glass-enclosed cupolas on top of the towers qualified men maintain a watch for the first sign of rising smoke that betokens the beinning of a fire. Equipped with binoculars, maps, and instruments, they are able to place the fires reasonably closely. When one is discovered the alarm is immediately transmitted by telephone to rangers or wardens, who are expected to be in readiness to start at once for the reported location of the fire. They are provided with up-to-date fire-fighting equipment. It still includes shovels and hoes, but increasing use is made of horse-drawn or motor-drawn plows and of special implements and machinery of various kinds. Water-throwing devices are very generally employed; they include not only knapsack pumps that are operated by hand but also portable power pumps that can be set down wherever water is obtainable and will deliver a stream through a hose to a fire that may be a mile distant. There are hundreds of these power pumps and thousands of the knapsack pumps in use today.

This is only a glimpse at a single part of the entire organization necessary for an efficient system of protection, but it will give some idea of the care and thoroughness with which the work must be planned beforehand and every eventuality made ready for. For fires which reach a size too great for one man to handle crews must be assembled and dispatched, in accordance with arrangements previously made for bringing them together and getting them off swiftly, with the necessary equipment and competent leadership. Fire fighting is an art which must be learned through special training and experience, and the leaders must be given this training if the crews are to function effectively. The greatest possible speed in discovering, reporting, and moving against the fire is one of the fundamentals; competence in handling it is another; not to leave until it is dead out, another. Detection and suppression, however, are far from constituting the full field of the activities of a modern protective organization. The State foresters lay nearly, if not fully, as much stress on measures of prevention.

Regulatory laws make possible some control of the conditions which tend to cause fires, and law enforcement through discovering the persons who have set or caused fires, collecting the evidence necessary to establish their guilt in a court of law, and bringing about their prosecution, is an important deterrent of subsequent negligence or incendiarism. Still more important is effective use of all possible instrumentalities of public education. The press, the radio, publications, lectures, moving pictures, and even proclamations by the governors are made use of.

There is pretty general agreement as to the best type of organization for a State protective system and the best methods to be used in the protective work, and the States are gradually approaching a common pattern. However, there is still a decided diversity in their organization, their methods of financing the work, the progress they have made, and the results they obtain. The State foresters are circumscribed in what they can do by controlling legislation and by their appropriations. The length of time that the Forestry Department has been engaged in the work of protection also has a good deal to do with the stage of progress reached and the results obtained. For example, educational work is cumulative in its results as the years pass.

Reference has already been made to the laws governing the appointment of the State foresters. In a number of States the position is one which may be subjected to political pressure. In a few cases this untoward influence may carry down through the field force of fire wardens or rangers.

The method provided for selecting the local field force differs rather widely. In some States, for example, Pennsylvania, New Jersey, and Connecticut, the wardens are chosen by the State forester. In other States, as in New Hampshire and Massachusetts, they are at least suggested by town officers, and in some of the far Western States the organization of the protective force is principally in the hands of timberland owners' associations. There are also wide differences in the method of financing the protection activity. In 18 States no part of the expense is borne by the private owner. In Kentucky, West Virginia, Montana, Idaho, California, Oregon, and Washington the expense is divided between the public and the landowners, the public share being derived partly from the Federal cooperative contributions and partly from State funds. Three of these States (Montana, Idaho, and Washington) confine the expenditures of their own funds to State-owned lands.

In New Hampshire, all owners of 1,000 acres or more must furnish protection up to a certain cost per acre. In Vermont, owners of unoccupied or unenclosed forest land may be called upon to meet a portion of the cost of suppression when it exceeds a fixed ratio of the taxes to be raised in a town. In the so-called "forestry district" of Maine, the fire protection funds are raised by a 2¼ mill tax on all property. Most of this region is timbered, so that the tax practically amounts to the timberland owners bearing the burden. In Connecticut, Maryland, Virginia, West Virginia, Wisconsin, Oregon, and Washington, a part of the expense is placed upon the counties; in California, a part may be assumed by the counties; in Maine (outside the forestry district), New Hampshire, Vermont, Massachusetts, Rhode Island, New York, and Wisconsin, a part is placed upon the towns. Meager State appropriations rather than laws have laid a large share of the cost of protection upon cooperating timberland owners in Alabama, Florida, Georgia, Louisiana, Mississippi, Oklahoma, and South Carolina, and to a less degree in Texas.

Except for relatively small areas, protection effort is now Statewide in most regions. In the central group of States, however, only about 30 percent of the area and in the southern group only 24 percent are under organized protection. Lack of sufficient money and the short time since protection activities were initiated are largely responsible for incomplete coverage of the area in these two regions. Dearth of funds is of course partly a reflection of lethargic public sentiment.

Results obtained by the States.—The results of organized protection by the States are more real than apparent. Along with the development of protection methods there has been taking place the tremendous development of automobile travel and road systems, which has brought a vast increase in the fire danger. Streams of people now pour year after year into and through the wooded country. Campers, picnickers, hunters, fishermen, and mere travelers along the roads make up a veritable host of potential fire causers. Rarely do they purposely set fire to the woods; ordinarily they doubtless never know it when they have been fire causers. The thoughtless discarding of burning matches and tobacco is an example of the forms of carelessness that may easily originate a fire which does not become evident until the person responsible for it is far on his way. On their face, the statistics relating to the number and the size of fires fail to give a fair picture of what has actually been accomplished in fire protection. This is notably true in the South, where, as protection has been extended more widely, better data on fires have been obtained, with the result that the count doubtless includes many fires about which, had they occurred in earlier years, nothing would have been known. Reports from Pennsylvania and Massachusetts, in both of which State-wide protection has been in effect long enough to make the data reasonably comparable for a series of years, show in one case an apparent trend in the direction of a smaller average size of fire and in the other a trend in the direction of a smaller number of fires. There are, however, too many variables that affect the record to permit of drawing any definite conclusion, one way or the other, from these figures. Table 4 shows the Massachusetts and Pennsylvania record.

TABLE 4.—*Number and average size of forest fires in Massachusetts and Pennsylvania by years, 1921–31*

Year	Massachusetts		Pennsylvania	
	Number of fires	Average size	Number of fires	Average size
		Acres		*Acres*
1921	2, 849	10	2, 384	78
1922	4, 099	21	3, 634	91
1923	2, 672	18	3, 539	106
1924	3, 735	13	1, 998	48
1925	3, 310	13	2, 603	49
1926	2, 860	12	2, 916	47
1927	2, 029	17	1, 247	30
1928	930	14	2, 534	44
1929	1, 198	14	2, 461	17
1930[1]	1, 922	38	[1] 6, 789	46
1931	1, 195	16	[2] 4, 014	37

[1] 1930 was a very severe fire year.

[2] 1931 was a severe fire year in Pennsylvania.

A comparison of the results of protection in the several forest regions will serve to throw light on what the States are doing. Various indicators of the accomplishments will be successively considered. It should be borne in mind that no one of these indicators by itself affords a satisfactory basis for judging as to the results. In combination, they bring out a single composite picture.

The diversity of conditions in the several regions has to be taken into account in interpreting the tabulated data. It is much easier in some regions than in others to make a good showing. Climate, terrain, the character of the vegetation, available roads, population density, water supplies, and the like interact with the preparedness, equipment, and general efficiency of the organization to affect the result. Again, the importance of confining all fires to a small area varies greatly. To attempt to give equally intensive protection everywhere would be unjustifiable; costs must be balanced against results. Where fires are likely to start at remote points in sparsely settled country and run fast through open forests or over grasslands without doing much damage, it would be extravagant to maintain a protective system designed to insure keeping all the fires small, and impossible to obtain a showing of results in this respect which would compare favorably with those easily attainable and necessary to seek under the opposite conditions.

In the section of this report entitled "Protection Against Fire" the regional expenditures for the protection of State and private lands are compared on the basis of the ratio between the annual expenditures and the total acreage of these lands needing protection. For the period 1927–30 the annual per acre expenditures averaged, on this basis, as follows:

	Cents		*Cents*
Central	0. 40	Lake	2. 01
South	. 43	Middle Atlantic	2. 77
South Rocky Mountain	. 89	Pacific coast	3. 28
New England	1. 94	North Rocky Mountain	5. 90

Neither as an indicator of the varying cost of adequate protection in the several regions nor as an indicator of the relative intensiveness with which the States are actually applying protection does this showing accurately reflect the situation. In the two regions in which the lowest expenditures are shown only a minor fraction of the forest area in need of protection is receiving it. The coverage in the central region is only a little more than one third and in the South only about one fourth complete. In all the other regions but one, however, it is close to complete, and in that one is more than 92 percent complete. Further, some expenditures are included outside those made in maintaining the State protective systems. With due allowance for these facts, the figures serve to give an approximate idea of the cost of the protection that is being given in these eight forest regions. The costs shown do not at all indicate the absolute per acre needs of the several regions and indicate only in a very rough and tentative way their comparative needs, concerning which more will be said later. It should be borne in mind also that the expenditures of the individual States within a region often vary substantially.

Table 5 compares the results during the period 1926–30, by regions, in terms of the total number of fires, the number per 100,000 acres protected, their average size, and the ratio between area protected and protected area burned.

TABLE 5.—*Regional results of protection as shown by the number and average size of fires and by the ratio between area protected and area burned over. Average for years 1926–30*

Region	Fires			Area burned per 100,000 acres protected
	Number		Average size	
	Total	Per 100,000 acres protected		
			Acres	*Acres*
New England	3, 643	11. 7	26. 3	308
Middle Atlantic	6, 590	21. 4	49. 7	1, 081
Lake	4, 918	9. 5	113. 3	1, 081
Central	2, 868	18. 8	96. 0	1, 803
South	15, 893	31. 0	106. 7	3, 301
Pacific Coast	4, 964	12. 5	192. 4	2, 415
North Rocky Mountain	1, 166	9. 3	93. 2	871
South Rocky Mountain	149	3. 2	33. 3	109

There is a discrepancy between the showing made in table 5 of the area burned per 100,000 acres protected and some apparently corresponding data in the sections of this report entitled "Protection Against Fire" and "Federal Financial and Other Direct Aid to the States." The discrepancy is due to the fact that, for the purposes of the present table, the area protected is reckoned on the basis of the entire area covered by the protective set-up, irrespective of the character of the cover. Brush and grass lands must often be protected along with forest lands if fire is to be kept out of the forest.

The last three columns in table 5 show the comparative standings of the regions when rated on the basis, respectively, of the number of fires for a uniform acreage under protection, the average size of the fires, and the average yearly burn for a uniform acreage. On each basis a different order is set up. Average expenditures per acre produced the order shown on page 809. None of these comparisons bring definitely into the picture such essential parts of it as the varying difficulty of the job and the degree of intensiveness of protection which the varying values at stake and their varying susceptibility to fire damage justify. Nor do they take into account what proportion of the entire area needing protection is actually receiving it.

Disregarding for the moment the showing of the South Rocky Mountain region, which is due to exceptional circumstances, not to intensive State protection, New England is here shown as outstanding in the low ratio of area burned to area protected. This reflects in part favorable conditions for keeping fires small, in part the fact that protection is strongly backed by public sentiment, well supported financially, well organized, and strengthened through long seasoning—a product of many years of continuous upbuilding. The North Rocky Mountain region takes its place next to New England, and slightly above the Lake region, in spite of the fact that it includes the part of the country where climate, topography, and wilderness conditions combine to make the problems of effective protection more difficult than anywhere else in the United States. In the North Rocky Mountain region the loss which may result from fires on the State and private lands covered by the State protective system is so great that the owners consider much heavier per acre expenditures than are made anywhere else fully justified. The average of nearly 6 cents per acre per year was shown on page 809 to be far above that of any other region; and even so, the average partially disguises the situation from the fact that it is held down by relatively low protective costs in southern Idaho and in eastern and central Montana, as compared with western Montana and northern Idaho, where the average expenditures may run more than twice as high as the regional average. It should be said, too, that the severest task of protection in this region falls upon the Federal Forest Service, in taking care of the national forests, which generally speaking are less accessible, higher lying, and of more rugged terrain than the State and private lands.

The South rates lowest in the comparative showing based on the ratio of burn to the entire protected area, partly because in the "piney woods" country fires easily run over large areas, often without doing much damage, partly because the custom of woods burning is deeply ingrained, partly because the State protective work is too new to have gained a very firm hold. In the central region also the work is relatively new, and further is not well supported, either financially or by public opinion; the per-acre expenditures in this region are the least anywhere. The Pacific Coast region rates between the Southern and the Central region, in spite of the fact that its average per-acre expenditures is exceeded only by that of the North Rocky Mountain region. This is chiefly due to the fact that in a large part of the Pacific Coast region protection is made difficult by a very protracted dry season, and brush and grass fires are likely to spread fast and run widely.

Of the seven States comprising the south Rocky Mountain region only three have entered into comparative agreements with the Federal Government for the protection of any State or private lands against forest fires, and of these three, two utilize in whole or in part the organization maintained for protecting the national forests in lieu of independent field organizations of their own. The total area of State and private lands in the South Rocky Mountain region given protection in the years 1926–30 exceeded 4,500,000 acres, but more than 96 percent of this area was protected by the national forest organization. In New Mexico, which obtains an allotment of Federal cooperative funds for protection, the actual doing of the work is made over entirely to the Forest Service under a special arrangement in the nature of a contract. This is because the State and private lands protected are either intermingled with national forest lands or so close to them that a single protective system affords the most practical and economical means of doing what is really all one job. In Nevada the Federal and State organizations, while mainly separate, partly coalesce. In the rest of the States in this group, except South Dakota (which has a field protective organization primarily to take care of the Custer State Park), such protection of State and private lands as is afforded by a public agency is given by the Forest Service in connection with national forest protection and in consequence of the fact that to protect the national forests it is necessary to protect also intermingled or adjacent lands not federally owned. To a small extent the apparent relationships shown in table 5 for other western regions may lack accuracy because of a similar inclusion of results of protection incidentally given by the national forest organization with the results of protection given through State protective organizations.

The South Rocky Mountain region affords less of an opening for State forestry than the other regions because the national forests include the great bulk of the productive timberlands. Also, the task of protection is lighter in this region than almost anywhere else. An evidence is the relatively low expenditures of the region shown on page 809; incomplete data indicate an expenditure of only 9 mills annually. On the other hand, New England and the Lake States spend about 2 cents an acre, the Middle Atlantic States about 2.75 cents, the Pacific Coast States about 3.25 cents, and the North Rocky Mountain region nearly 6 cents.

To obtain a means of setting up suitable standards of performance or objectives in protection, and to provide a criterion for judging the satisfactoriness of the actual performance measured against the objective, the Forest Service and a number of the States employ a method of rating comparative protection requirements in terms of what is known as "allowable burn." This is an arithmetically expressed judgment of the maximum amount of injury by fire that a given type of forest can be subjected to without serious impairment of the forest values basic to the predominant purposes of management. While the damage done to the forest by individual fires varies widely, even in a given type of forest, depending upon the intensity of the fire and the particular condition of the area, if a sufficiently large area is under consideration it is possible to fix upon a protection objective based on average consequences. Over a long term of years, if the annual burn does not average above a certain small percentage of the total area under protection, the aggregate injury done will not, from the standpoint of the total area, generally defeat the purposes of management—though it may in individual cases; just as a satisfactorily efficient city fire department provides no guarantee that an individual business with fire risk uncovered by insurance may not be bankrupted by a bad fire on its premises, or that a conflagration may not deal the whole city a severe blow. In other words, "allowable burn" does not mean that if fires are held, over a term of years, to an area limitation of a certain annual percentage of the entire area protected, damage will be eliminated or ruinous losses will universally be put an end to; but it sets up an objective of public policy based on what appears to be necessary in the interest of the general welfare. Beyond that, the problems are individual and are left to the individual.

Whether protection that conforms with standards thus established may appropriately be designated as "satisfactory" depends on the meaning attached to this word. To assume that any standards now set up will be permanently satisfactory would be unwise. Time brings progress. Whether the passenger automobiles of today can be termed satisfactory machines depends on the viewpoint. Certainly they are not satisfactory to their manufacturers; each year sees changes in the models. So it is with forest-fire protection. One or more States are even now keeping their fires within limits that they set up as objectives a number of years ago. Most of them are not, but they are striving for it. Some may not be making rapid progress, for reasons beyond their control. Some may have set up goals beyond their reach, beyond what the State and cooperating agencies can or will pay for at present. In no case, however, is the organization resting on its oars. Improvement of the personnel, of the equipment, of relations with the public, and of methods are being sought even in the States that are already accomplishing all that they set out to do.

In another section of this report, entitled Protection Against Fire, the authors have set up standards by which to rate the adequacy of the protection now being given the forests of the country regionally, through a comparison between "allowable burn" and actual burn. Table 6 shows the results obtained in the 5-year period 1926–30 and the relationship between these results and the degree of intensiveness of protection which would be necessary to make the average annual burn equal to the "allowable burn" as estimated by the Forest Service, on the basis of present knowledge. The 5-year period is too short to afford an entirely dependable basis for a rating of the performances; but the progress that is steadily being made by the States in the effectiveness of the protective work and in the extension of the area covered would tend to make the showing less, rather than more representative were the record prior to 1926 included. Because the figures for the South Rocky Mountain region do not represent the results of organized protection administered by the States themselves, this region is not brought into the showing.

TABLE 6.—*Regional results of protection as shown by the ratio of the "allowable burn" to the area burned over annually*

Region	Allowable burn	Protected area		Total area (including unprotected)	
		Actually burned 1926–30 average	Percent adequate	Actually burned 1926–30 average	Percent adequate
	Percent	*Percent*		*Percent*	
New England	0.16	0.31	51.6	0.31	51.6
Middle Atlantic	.35	1.08	32.7	1.04	33.7
Lake	.36	1.08	33.3	(1)	(1)
Central	.59	1.80	32.8	3.16	18.7
South	1.34	3.30	40.6	19.01	7.0
Pacific Coast	.49	2.41	20.3	2.43	20.2
North Rocky Mountain	1.05	.87	120.7	1.04	101.0

(1) Data not available.

Measured by this yardstick, the North Rocky Mountain region makes the best showing, New England comes a long distance below, and the other regions take their places still farther down.

Conditions necessary for efficiency.—Various reasons may account for an unsatisfactory situation, where one exists—personnel, type of organization, political interference, lack of suitable legislation, inability to obtain law enforcement, lack of money, newness of the work, and so on. The most important single requirement for success, of course, is suitable financial support.

Most States have not as yet provided adequate financing of the job. The total estimated cost of adequate protection as worked out in 1930 for each State by the individual State forestry departments in cooperation with the Forest Service was $13,386,000; while calculated by regions on the basis of the standards set up in the section of this report entitled, Protection Against Fire, the total estimated cost of adequate protection is placed at approximately $20,000,000. The State budgets for 1933 provide a total of $6,142,500; this includes all State, Federal, and private funds that will be available for expenditure under State supervision. While these budgeted expenditures will be considerably augmented by independent private protection work, the gap left will still be of very formidable dimensions.

Of equal importance is stability of funds. To have an effective organization there must be a substantial measure of permanency in the field force, so as to build up and utilize experience. Wide fluctuations in the financial provisions for the work disrupt its continuity. Where dependence must be placed principally or largely upon private cooperative funds, or game and fish license receipts, or taxes upon timber or timber products, the revenue is likely to fluctuate, making the organization unstable. Several of the Southern States derive most of their financial support other than the Federal contribution from the voluntary cooperation of private owners, which in times of depression falls off materially. In a few of the far Western States, where private participation in the expense of protection is required by law, participation can be avoided by allowing the lands to revert for taxes. There is no assurance of continuous protection of the lands after they have been logged and the valuable merchantable material removed. Their owners may feel it economically unsound to meet the cost of protecting cut-over lands. That receipts from severance taxes or other special taxes form an uncertain source of funds is exemplified by the case of one of the Southern States, in which a fall in the proceeds of a special tax from about $50,000 in 1928 to $20,000 in 1932 necessitated a reduction of 3½ million acres in the forest area protected and forced the dismissal of several of the key men in the State organization.

Next to the amount of money available for the support of the work, the most important factor in determining the degree of success is personnel. Everyone will concede that there are differences of ability in the personnel of the many State organizations, both in the higher and in the subordinate positions. It could not be otherwise. It is reflected, naturally, in the accomplishments. Good men even in a poor type of organization will accomplish a great deal.

Yet they cannot accomplish the impossible. They can only very gradually reduce the number of fires and area burned. Bad years will completely upset their record. They cannot change lifetime woods-burning habits or woods-burning indifference amongst the great mass of the population of a State without years of persistent and patient effort. The fire record of the South suffers because of the fact that protection is a comparatively recent undertaking in that region. It will improve; it has already improved greatly, as a result of organized effort, in much of the region. Protection cannot be so good, other things being equal, in a State that has only undertaken the job within the last 5 years as in one that has been at it for 20 years. It takes time to build up public interest, methods, the physical plant, and personnel.

Developments in State forest fire protection have come along gradually. They will doubtless proceed gradually in the future, with acceleration particularly in the Southern and Central States. There will be no overnight changes. The principles underlying success in this activity, however, are now well known in all States, the technique applied to the job is improving, the suppression equipment is vastly better than formerly and is constantly being added to and improved (use of the airplane and the radio are recent developments), and public sentiment is increasingly favorable.

The State organizations have directed their effort and thought upon the forest fire problem to good effect. Given the funds, the legislation, and the time, they have demonstrated their capacity to cope with it. Their understanding of local conditions, habits of the people, and sentiment has been a big factor in their progress. It seems evident that centering forest fire protection of State and privately owned lands in the State organization is the key to its successful prosecution. There is no good reason for other than steady progress in this field. The work will, of course, be more capably administered in some States than in others. Situations will doubtless arise that will call for a change in personnel. Additional legislation is necessary here and there; more emphasis could well be placed on prevention measures; but, in the by and large, sufficient funds and time are the two main essentials.

Forest fire protection is now handled as a joint cooperative enterprise of the States and the Federal Government. Aside from the Federal funds supplied, the newly organized State forestry departments, at least, are tremendously benefited by having thus made available to them the fund of experience gained in the protection of Federal forest lands and in the protective activities of other cooperating States. The history, progress, and results of this cooperative enterprise are discussed fully in the section Federal Financial and Other Direct Aid to the States.

It cannot be expected that the set-ups for protection in the various States will all fit precisely the same pattern. At least there will be differences in details. Nevertheless, from experience gained to date, it seems possible to outline the general features best adapted to meet the needs.

Forest protection against fire is a specialized activity. During the last 30 years there has been built up a body of knowledge of the behavior of fire under varying conditions, the causes of fire, and the most effective methods of preventing and suppressing fires, which warrants calling the protection job a technician's job. While forest protection against fire is not by itself the practice of forestry, nor is a technician in protection necessarily on that account a technical forester, the art and the science of fire control pertain to the art and the science of forestry, and other things being equal, a protective organization in which well-trained and experienced technical foresters largely fill the higher positions is much more likely to be effective than an organization little influenced by professional education, contacts, and attitudes.

This is the more important because as a public activity protection should be directed from a forestry viewpoint. Its objectives are forestry objectives. It should be planned along lines designed primarily to safeguard the future welfare and productiveness of the forest as a resource, not simply to safeguard private property in standing timber. Consequently, while it would be erroneous to hold that a good administrator of a State system of fire protection cannot be developed from a capable woodsman qualified for executive and managerial responsiblities but untrained in technical forestry, as a rule and in the long run recognition of the job as one which should be either performed or supervised by a trained forester will bring the best results.

Were the protective work the only need of the State in forestry, the advantage in having a technical forester in charge of it, as against a competent nontechnical man with the right viewpoint, would not always be very material. But the interests of the States call for a work of all-around leadership toward better use of the forest resources. Rarely is the undertaking of the State in forestry confined wholly to protection. Even where the immediate reason for organizing a forestry department has been to provide the machinery necessary in order to qualify for Federal cooperation in the work of protection, the basic law ordinarily contemplates other activities. The State forester's function normally includes a broad leadership in forestry generally through enlightening the public, assembling the information necessary to guide the development of a sound State policy of forestry, and giving expert advice in the fields both of public and of private policies and practices. In addition the State forester may and ordinarily does have technical duties either of forest land administration or of forest-nursery management.

It has already been brought out that in an overwhelming majority of cases State departments of forestry are now headed by technically trained foresters, although only in a small minority of cases is this required by law—plain evidence that the desirability of placing the work in the hands of professional foresters has been generally recognized. Some States make legislative provision for a chief fire warden under the State forester. Where the position is not specifically created by law, the typical organization of the work of his department set up by the State forester usually places one man in general charge, under him, of the protection activity. A functional staff organization in the State forester's office with specialists in charge of the several lines of work is customarily supplemented by a territorial organization under which the State is divided into districts, each with a district forester in immediate charge, in varying degree, of all the activities of the Department within his territory. This general form of organization corresponds closely with that of the Forest Service for the entire country, and has pretty well established itself as the most effective type of set-up where the work has attained important dimensions, with diversified activities. The local wardens or rangers, lookout men, and other members of the field protective organization are under the direct supervision of the district foresters, who should generally so far as possible be men of professional training.

As in any private business, the efficiency and competence of a State forestry organization is determined by the efficiency and competence of its chief executive within the limits of the possibilities afforded by the resources at his command and the conditions with which he is confronted. Nothing is more important than a machinery of organization likely to obtain a State forester who, in addition to being a technically trained man of good experience, has the initiative, energy, sound judgment, ability to lead and to inspire confidence, and other qualities essential for a successful executive. This is a matter, first, of selection, and secondly, of oversight. There must, of course, be oversight, to assure that the responsibilities of the position are fully met, and means of bringing about a change where the best interests of the work call for a change of leadership. How to obtain in the administration of public enterprises high-grade executive ability and how to provide for a proper oversight of the way in which responsibilities are discharged is one of the problems of government.

The greatest obstacle to more satisfactory conditions is the degree to which divided purposes enter into the administration of the public activities. In the struggle of contending parties, groups, and individuals for political power the use of offices, of the public payroll, and of administrative courses and decisions as aids in gaining or holding power is bound to take place unless there are restraining forces or bars. Hence the development of devices designed to enable administration to be carried on with as much separation as possible from political considerations in the narrow meaning of the term. Essentially, they are devices to protect the public against political racketeering. Civil service laws to insure the filling of positions on a basis of merit, the elimination of incompetent employees, and the protection of all incumbents against dismissal, demotion, or failure to receive advancement on other grounds than the efficiency of the work are one of the devices to this end.

Their use in State governments is, as a rule, rather limited. Whether or not they are used, they do not obviate the need for some means of obtaining accountability of the man at the head of an organization for the quality of performance of his unit, or for means of directing policies and tying them in with the general program and purposes of the State government as a whole. To meet the latter need, the device of directive boards or permanent commissions intended to function essentially as do the boards of directors of corporations has been widely used.

There are some obvious drawbacks to this form of organization. On the other hand, it has some outstanding merits, and in the main appears to meet most closely the needs of State forestry work. This is most true before the department has attained the stability and prestige that come with time and widespread popular endorsement of its activities.

Sound principles of administration may seem to be violated by a plan which diminishes the control of the Governor of the State, as its supreme executive, over all its departments. The multiplication of semi-independent departments through the setting up of one commission after another has undoubtedly tended to make State governments unduly complex, cumbersome, decentralized, and expensive. For one thing, this increases the difficulty of firm fiscal control. On the other hand, oversight of the work of the State forester by a nonpolitical board with staggered terms of several years not only safeguards the work very substantially against being politicalized but also pretty well guarantees stability of policies. With an interested and capable board, it affords wise guidance of the department, support of and assistance to the State forester in accordance with his merits and the need of assistance from his directors to accomplish his purposes, and a suitable body for sizing up his efficiency and, in case of need, replacing him by a stronger man. But to obtain these results the board must be in fact nonpolitical as well as capable; must command enough public confidence in both respects so that neither its motives nor the soundness of its judgment will be open to reaonable suspicion; and must be sufficiently interested in the work to be always in full touch with it. Such results are not assured merely by setting up the board or commission form of organization.

It goes without saying that, whatever the method provided for selecting the State forester, merit only should govern both his appointment and his retention in office. In public business, as in private, nothing else plays so large a part in determining success as the qualifications for his job of the man in charge. Two dangers to be particularly guarded against in public administration are, on the one hand, that mediocre men will be put in and, having once got in, will become permanent fixtures, and, on the other hand, that good men will not be given the support and the freedom from political interference necessary for large accomplishment. With conspicuously competent State foresters in every State, properly backed up by public opinion and given a fair chance by the State, the forest situation of the country would take on a different aspect.

The subordinate year-long personnel of the departments should be subject to the same conditions of appointment and retention on a merit basis solely as the State forester himself; their choice should be in his hands. The field force of part-time men, ordinarily called fire wardens and patrolmen, should be subject to supervision by the State forester, should also be chosen and retained on the basis of merit only, and preferably should be appointed by the State forester without interference from other sources; if they are appointed or suggested for appointment by town or county officials, the State forester should have absolute authority to approve or reject them and to dismiss them for cause.

The organization should embody to a well-balanced degree the features of prevention, detection, and prompt suppression of fires.

Well organized prevention must give an important place to vigorous and sustained educational activities, conducted through varied means of reaching the public, which should include suitable provision for press contacts and publicity. Prevention should include also the taking of special precautions during the dangerous fire season—sending out fire warnings to the public, the use of patrolmen, close cooperation with the State police, strict enforcement of laws, such as the permit and the brush disposal laws, designed to hold in check the originating and the spread of fires, and closing of the woods when necessary by proclamation of the governor. Prevention of fires should have a more prominent place in the picture, be given more persistent attention, than is commonly the case now.

Detection of fires should be provided for by well constructed and well distributed observation stations, each in charge of a man supplied with equipment for locating fires and connected by good telephone service with the fire suppression forces. His duty is to discover and report promptly woods fires that come within his vision. He should be closely supervised by his superior officer. Detection may require the use of airplanes now and then, at times when the observation stations are not effective or in places where they do not sufficiently command a view of the entire terrain. The major uses of airplanes in protection, however, are now in suppression activities, to scout fires and to transport men and supplies rapidly. Detection should be improved by inducing landowners, residents, and the traveling public to report all fires promptly.

The State suppression force must be organized with two fundamental points in mind. The first is that of starting promptly to a fire with equipment and men as soon as it is reported; the second is that of staying with it until it is dead out. Presuppression activities, getting ready for fires, should be well looked after. Equipment should be purchased, put in first-class shape, and made available for quick use; needed roads and trails should be developed as rapidly as possible; sources of water should be located, marked, and improved; the men in permanent employ should be schooled and trained in the best known methods of fire suppression; they should be required to know their territory intimately; crews of fire fighters should be organized beforehand wherever that is possible; and arrangements should be made in advance for transportation, food, and other supplies for fire fighters in those relatively inaccessible regions where it is necessary to provide camps for the men. Preparation for fires and training of men to apply the most up-to-date suppression technique known are the two main essentials of success.

The methods set up for protection are in a constant evolutionary process. They are being improved all the time. The emphasis given to various elements of the field organization will vary by States and regions. Forces of men that can be quickly mobilized and transported to the fires are fundamental features. Up-to-date equipment in good repair and in sufficient quantities is essential. Adequate and competent supervision of the fire-fighting crews is tremendously important. And last, determination and everlasting persistency until a fire is completely extinguished are necessary.

State ownership and management of forest land may be the key to successful forest fire protection in some States. The man in charge of a State forest and the crew of men working there can very well be the nucleus of the fire-fighting force that serves the surrounding region. Where this plan is already in effect, it is proving very satisfactory. It seems like the logical development in any State that is building up a system of State forests.

Division of costs.—Table 7 shows, by regions, the present distribution of the costs of maintaining the State systems of cooperative protection.

TABLE 7.—*Distribution of cooperative fire protection costs among the participating agencies by regions, fiscal year 1932*

Region	Expenditures				Distribution of expenditures		
	Total	Federal	State, county, and town	Private	Federal	State, county, and town	Private
					Percent	*Percent*	*Percent*
New England	$500, 771	$132, 047	$354, 930	$13, 794	26. 37	70. 88	2. 75
Middle Atlantic	1, 039, 271	173, 166	863, 743	2, 362	16. 66	83. 11	. 23
Lake States	1, 547, 323	278, 746	1, 246, 361	22, 216	18. 01	80. 55	1. 44
Central	217, 482	90, 499	107, 920	19, 063	41. 61	49. 62	8. 77
South	900, 633	407, 989	313, 341	179, 303	45. 30	34. 79	19. 91
Pacific Coast	1, 258, 231	386, 133	298, 098	574, 000	30. 69	23. 69	45. 62
North Rocky Mountain	459, 606	99, 396	86, 333	273, 877	21. 63	18. 78	59. 59
South Rocky Mountain	17, 796	4, 387	4, 081	9, 328	24. 65	22. 93	52. 42
Total	5, 941, 113	1, 572, 363	3, 274, 807	1, 093, 943	26. 47	55. 12	18. 41

A glance at the percentages in the last three columns of the table shows great variations between regions in the relative share of the Federal Government, the State and local governments, and the private owners. Thus, in the Middle Atlantic region the private contribution in 1932 was only a small fraction of 1 percent of the total, in the Lake region it was less than 1.5 percent, and in New England was 2.75 percent, but in the South it was nearly 20 percent and in the 3 western regions ranged from a little less than 46 percent up to nearly 60 percent. The Federal contribution was greatest in the South, where it exceeded 45 percent, and least in the Middle Atlantic region, where it was less than 17 percent; while the share carried by the State and local governments was greatest in the Middle Atlantic region (more than 83 percent) and least in the North Rocky Mountain region (less than 19 percent).

Space does not permit going very far into the reasons, important though they often are, for these regional variations; but it is necessary to point out in a broad way what the variations signify.

The Weeks law, which inaugurated the policy of Federal cooperation, merely required a State contribution at least equal to the Federal. The Clarke-McNary law of 1924 brought the private owners into the picture. The law was based on a conception of the work of protection as one in the benefits of which the Nation, the States, and forest-land owners would all participate and towards the cost of which all three of the parties in interest should contribute. In the hearings on the bill prominence was given the idea that a reasonable and fair apportionment of the cost would be obtained if the Federal Government and the States should each pay one fourth of it and the private owners one half. As a measure of the extent of the Federal responsibility, this 1–1–2 ratio has ever since the passage of the law been widely accepted. Table 7 shows that Federal expenditures in 1932 made up 26.47 percent of the total.

The Clarke-McNary law, however, did not place any closer limitation upon the Federal share of the cost than the old Weeks law limit of 50 percent; and it broadened the earlier law by permitting county, town, and private contributions toward maintaining the protective system to count as part of the expenditures which the Federal Government might match. It was not the purpose of the law to lay down hard-and-fast requirements for the States with respect to distributing the costs. What was sought was the enlistment of all the agencies having interest, under such a form of arrangement as might be held by each State most feasible and appropriate to its own conditions. Consequently, the legislation has afforded a highly flexible basis for building up Nation-wide protection adjusted to local situations and regional needs and possibilities.

One of the objects sought in administering the Federal cooperative work has been to extend as much encouragement as possible to the States for its inauguration and to help get it on its feet after it has been inaugurated. In some cases this leads to allotments of Federal funds substantially equal to one half the total expenditures. The relatively high percentage of the Federal contributions in the southern and central regions shown in table 7 is thus explained.

The greatest divergence as between regions appears in the last column of the table, with a spread in the private expenditures from almost nothing in the Middle Atlantic region to nearly 60 percent in the North Rocky Mountain region. Conversely, the State, county, and town, contributions in the first-named region were 83 percent, but in the second-named were only 19 percent. While some eastern States require (as was previously pointed out) the payment by private owners of a certain part of the protection costs, the general trend in the East, except in the States embraced in the southern region, has been toward recognizing protection as primarily a public obligation. Nowhere has the conception of a Federal, State (or State, county, and town) and private sharing in the cost on one-fourth and one-half basis been accepted and applied as a working principle—although the Pacific Coast group of States collectively happen to show a fairly near approach to this distribution. In the West the inclination has been to require the private owner to bear most of the cost, beyond that met through Federal participation. The State contribution in several of these States is largely because of State land ownership, for the protection of which the State pays on the same basis as would a private owner, in proportion to the acreage owned. Were a deduction made of expenditures to protect State lands, the relative participation of the Nation, the States, and private owners in protecting private lands would show up in somewhat different ratios from those presented in table 7.

In the South, where the Federal Government bears for the region as a whole 45 percent of the cost, the States and local governments 35 percent, and the private owners 20 percent, the newness of the work in most of the region, the relatively small scale on which the States are prepared to finance the protective effort from their own treasuries, and on the other hand the desire of a good many landowners to obtain protection of their lands, have made this the only part of the East in which the private contribution makes up a substantial part of the total. The percentage derived from this source in some of the Southern States is considerably greater than for the region as a whole.

It should always be borne in mind that what is under discussion in this section is the protection against fire provided by means of organized State activities, as a public function. Private owners may, and in many cases do, make individual expenditures for the protection of their own property independently of the public protective system, just as the owners of factories, stores, and residential properties in cities supplement the protection afforded by municipal fire departments and regulatory ordinances, through private installations and precautionary measures of various kinds. Table 7 takes no account of such supplementary forest protection outlays by individuals.

The distribution of costs as between the State on the one hand and the counties or towns on the other hand takes many forms. Sometimes it is a matter of individual arrangement. Frequently either one half or all the cost of suppression is borne by the local units of government—sometimes as an initial outlay, sometimes through a requirement of reimbursement of expenditures made by the State. Oregon and Washington require the counties to meet one third of the State protection expenditures for all purposes, and Rhode Island requires the towns to meet the entire cost but reimburses them for half the outlay; and there are other forms of division. The requirement of an assumption of part of the cost of suppression by the local political units seems desirable. It brings closer home the feeling of responsibility for conditions likely to lead to fires, is thus of educational value, and may have a preventive effect.

PROTECTION AGAINST INSECTS AND DISEASES

There has been no development of State organizations to meet the damage and destruction caused by forest insects and forest-tree diseases comparable to that for combating forest fires. This is not because the damage from the former sources may not be great, but because it is less spectacular, more insidious, and does not endanger human lives. Further, widespread infestations are more difficult if not more expensive to combat successfully. Great areas of forests are laid waste by insects, and disease takes a tremendous toll of forest trees either by killing them outright or by causing decay. The white-pine blister rust is being strenuously combated by the cooperative efforts of the Federal, State, and town governments and private owners. Large sums of money are being spent in this effort.

The gypsy and brown-tail moths (both insects introduced from abroad) have been particularly destructive to forest trees in the northeastern States; heroic efforts and tremendous sums of money have been spent by the States, Massachusetts in particular, to combat them. The States have not succeeded in controlling the gypsy moth; they have kept down its numbers, but now it threatens to extend its range westward and southward.

In Maine large areas of spruce and fir have been killed by the spruce bud worm, and attacks of the birch leaf miner are reaching alarming proportions. A well-balanced entomological staff in Maine keeps in close touch with insect depredations through the forest fire organization, conducts careful studies, and makes recommendations for control.

New Hampshire, Connecticut, and Ohio have made notable progress in investigations of forest-tree insects.

Laws of California, Massachusetts, New York, Oregon, and Vermont make it possible to require owners of property infested with insects to take measures necessary for their control; those of Maine and New Hampshire permit enforcement of private control measures for white-pine blister rust, while those of New York and Vermont do the same for any injurious diseases of forest trees.

REGULATORY REQUIREMENTS

The State laws which impose restrictions upon private owners in the United States are discussed in the section of this report entitled Public Regulation of Private Forests. As is there shown, except in Louisiana and New Hampshire State regulatory laws have not had in view the requirement of practices of utilization designed to assure the establishment of a new forest crop on the land cut over, but have been limited to requirements relating to the control of fire, insects, and disease. Of these the requirements designed to lessen the fire danger are the most extensive and important at the present time.

It is true, of course, that protection from fire is essential to the establishment of a satisfactory new growth, and that with adequate protection after lumbering forest perpetuation will in many cases be accomplished without the application of silvicultural practices in cutting the old stand; but broadly speaking, the objective of State requirements relating to compulsory patrol, slash disposal, snag felling, and the like is to prevent the spread of fire to surrounding property and to facilitate the task of fire suppression as a general public undertaking, rather than to maintain in a productive condition the particular piece of land in immediate question. Regarded from this standpoint, regulatory requirements relating to fire control are largely a form of State aid to enterprises of forestry, supplementing and integrating with the aid extended through organized systems of protection.

Legal restrictions or regulations are one thing; their observance and enforcement are another. The regulatory restrictions imposed by State laws upon private owners of timberland are in some cases well observed and enforced, in a few practically inoperative, and in others feebly or unevenly operative. Lack of observance by private owners may be due to unfamiliarity with the laws, or to a lack of respect for or belief in them, or to desire to escape expense. Their enforcement by the States is not all that could be wished. Among the reasons are the small number of men available for the work, the extent and difficult character of the terrain which has to be covered, the hostility and obstruction often encountered, the lack of cooperativeness in some cases on the part of the State's legal officers, and the political influence which some law violators have and can bring to bear. It must be said, moreover, that very commonly the State organizations are not disposed to insist upon complete compliance with the law or regulations. This is apparently due to the belief that too strict methods will react unfavorably to their organization and to the accomplishment of their objectives.

It is not surprising that reports concerning some States indicate that of the regulatory measures relating to fire protection, the laws requiring slash disposal and snag felling are not so well observed or enforced as they might be, that costs of compulsory patrol are not assessed in full against individual land owners, and that individuals responsible for forest fires are not always punished. Nor have the regulatory laws which in two States provide for leaving seed trees, under certain conditions, on land that is being logged been generally observed or enforced. It is encouraging, however, that the enforcement of regulatory protective measures is improving, and is now much better than it formerly was. With increasing public interest and support, the task will grow less and less difficult.

The prospect for State regulation of logging operations is much more dubious. As a rule, there is little public demand for it, or persuasion that the public interest is in fact materially involved. An exception to this is found in some of the States in which water resources are of highest importance, and in one or two of these proposals of regulatory laws designed to assure the protection of watersheds are not unlikely to be advanced at almost any time, with strong backing of public sentiment. The regulation of logging operations by single States is certain to be made difficult by the objection that the operators might, and in some cases probably would, be placed at a financial disadvantage as against operators in other States; though intelligent regulation might sometimes have the effect of increasing rather than decreasing the operator's net returns. Legislation might easily be too ambitious, unnecessarily restrictive, founded in fact upon too little knowledge either of the art of woods management or of the operating problems of the lumberman. If the regulatory laws proposed were of the type in effect in Sweden, where local boards on which lumbermen are represented prescribe the measures to be followed on each particular piece of timberland cut over, opposition would doubtless be more readily overcome and in time something practically useful might be worked out. Effort directed along this line would be a forward step.

STATE FOREST LAND ADMINISTRATION

STATE FOREST LAND OWNERSHIP

In past years the Forest Service has at various times obtained from the several State forestry departments data on State forest holdings, classified under the three heads of State forests, State parks, and other forest lands. The classification was made by each informant in accordance with the local terminology or point of view; and this introduced various inconsistencies. The most recent compilation of the data thus obtained, made under date of July 1, 1932, showed a total of 7,822,439 acres of State forests, 730,293 acres of forested or chiefly forested State parks, and 5,336,460 acres of other State forest lands. The present report, based on other data, makes a considerably different showing. The difference is mainly due to a more systematic procedure, designed to classify on a clear-cut, consistent basis throughout.

To obtain a uniform classification a set of definitions was drawn up. State forests were defined as individual land areas either specifically set aside by legislative act or established under legislative authority contemplating their permanent retention and administration by the State for forest (as distinguished from essentially park) purposes, and organized in definite units of administration; while State parks were divided into two classes, those chiefly forest and those not in major part forest land. State parks falling in the latter class are left out of consideration in this subsection. The definition adopted for the former class limited them to areas maintained to serve public recreational and inspirational (scenic) needs, with or without watershed protection as a secondary objective, and with the utilization of commercial products either prohibited or severely restricted. The criteria thus set up afford, it is believed, a more accurate picture of the situation with respect to State forests than has previously been drawn, provided it is borne in mind that in several States the definition shuts out a large area having a certain measure of qualification for the name. The excluded lands are neither organized forest units established with legislative sanction nor forest lands entirely unreserved and awaiting disposal, but are intermediate between the two. Of them more will be said presently.

In the section of this report entitled Forest Land the Basic Resource the area of forest land in State, county, and municipal forest ownership is given as 10,632,000 acres. In the present subsection an aggregate of more than 13,200,000 acres of forest land is shown as in State ownership, and the following subsection, Community Forests, shows 1,000,000 acres in these forests. The above figure of 10,632,000 acres, however, embraces only commercial forest land, suitable and available for the growing of timber of commercial quantity and quality. It therefore excludes forest areas withheld from use for timber production in order to safeguard higher public values for such purposes as recreation and scenic or watershed protection. For example, forest lands within State parks are outside the reckoning. While its showing of area in State, county, and municipal ownership is based on other data than those more recently gathered for the present and the following subsections, the amounts here shown are in approximate accord with the earlier total; for omitting State parks, they aggregate a little more than 11,500,000 acres, not all of which could be classed as available for commodity production.

Tables 8, 9, and 10 present the results of the restudy of State forest land ownership made for the present report.

TABLE 8.—*State-owned forest land under administration as State forests and parks, by regions and States, 1932* [1]

Region and State	State forests				State parks [2]		Total net area
	Units	Net area	Land in process of acquisition	Ultimate area under present State policy	Units	Net area	
	Number	*Acres*	*Acres*	*Acres*	*Number*	*Acres*	*Acres*
United States total	405	4, 395, 549	2, 231, 636	12, 770, 000	323	2, 682, 509	7, 078, 058
New England:							
Connecticut	17	61, 714	1, 927	250, 000	34	9, 246	70, 960
Maine					1	5, 760	5, 760
Massachusetts	48	120, 000	2, 000	150, 000			120, 000
New Hampshire	24	32, 754		(3) (4)			32, 754
Rhode Island	2	410	100	(4)	13	3, 358	3, 768
Vermont	20	40, 960		100, 000	5	1, 348	42, 308
Total	111	255, 838	4, 027	500, 000	53	19, 712	275, 550
Middle Atlantic:							
Delaware	1	51					51
Maryland	10	50, 310	1, 124	200, 000			50, 310
New Jersey	8	48, 143	7, 555	200, 000	7	13, 306	61, 449
New York	168	74, 450	72, 130	1, 000, 000	55	2, 373, 804	2, 448, 254
Pennsylvania	20	1, 573, 754	40, 000	3, 000, 000	1	6, 055	1, 579, 809
Total	207	1, 746, 708	120, 809	4, 400, 000	63	2, 393, 165	4, 139, 873
South:							
Alabama	12	8, 905		20, 000	1	421	9, 326
Arkansas	1	25			1	1, 023	1, 048
Florida					1	4, 000	4, 000
Georgia	1	166			2	178	344
Louisiana	2	5, 888			2	318	6, 206
Mississippi	1	[5] 23, 000					23, 000
North Carolina					2	1, 464	1, 464
Texas	4	6, 434		100, 000	42	4, 131	10, 565
Virginia	1	588					588
Total	22	45, 006		120, 000	51	11, 535	56, 541
Central:							
Illinois	1	3, 320			3	2, 785	6, 105
Indiana	5	23, 500	3, 000	100, 000	9	10, 535	34, 035
Iowa				(6)	31	7, 031	7, 031
Kansas						1, 318	1, 318
Kentucky	1	3, 624			7	4, 451	8, 075
Missouri					9	41, 133	41, 133
Nebraska						2, 661	2, 661
Ohio	8	52, 250	400	150, 000	12	5, 229	57, 479
Tennessee	1	39					39
West Virginia	2	15, 393				227	15, 620
Total	18	98, 126	3, 400	250, 000	71	75, 370	173, 496
Lake:							
Michigan	12	779, 773	83, 400	2, 500, 000	49	29, 277	809, 050
Minnesota	13	1, 030, 195	1, 700, 000	4, 000, 000	8	38, 900	1, 069, 095
Wisconsin	4	111, 100	320, 000	1, 000, 000	12	11, 552	122, 652
Total	29	1, 921, 068	2, 103, 400	7, 500, 000	69	79, 729	2, 000, 797
North Rocky Mountain:							
Idaho					1	5, 505	5, 505
Montana	7	203, 000					203, 000
Total	7	203, 000			1	5, 505	208, 505
South Rocky Mountain:							
South Dakota					1	61, 000	61, 000
Pacific Coast:							
California	3	[7] 9, 933			14	36, 493	46, 426
Oregon	1	70, 113			(8)		70, 113
Washington	7	[9] 45, 757			(10)		45, 757
Total	11	125, 803			14	36, 493	162, 296

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[1] States which own neither State forests nor State parks are omitted. They include Oklahoma and South Carolina in the South region, North Dakota in the Lake region, and Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming in the South Rocky Mountain region.

[2] Only forested State parks included.

[3] No further purchase.

[4] Will accept gifts of land.

[5] Land owned by State University; administered by State forester.

[6] Survey now in progress which may yield recommended program.

[7] Includes a land exchange nearing completion.

[8] Oregon has 122 State parks containing 6,823 acres, the forested portion of which is unknown; not included in totals.

[9] Mostly logged-off land.

[10] Washington has 10 State parks containing 6,115 acres, the forested portion of which is unknown; not included in totals.

TABLE 9.—*State-owned forest land not under administration as State forests and parks, by regions and States, 1932* [1]

Region and State [2]	Unreserved Federal grant lands	Lands acquired by—			Total
		Exchange	Purchase and gift	Other lands	
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
United States total	4, 621, 778	453, 243	520, 156	544, 929	6, 140, 106
New England:					
Connecticut				[3] 2, 428	2, 428
Maine			187	[4] 400, 000	400, 187
Massachusetts				[5] 12, 500	12, 500
New Hampshire				1, 533	1, 533
Rhode Island				500	500
Vermont				200	200
Total			187	417, 161	417, 348
Middle Atlantic:					
Delaware				[6] 91	91
Maryland				5, 246	5, 246
New Jersey				4, 291	4, 291
New York			43, 288		43, 288
Pennsylvania			[7] 291, 240		291, 240
Total			334, 528	9, 628	344, 156
South:					
Alabama	270, 000				270, 000
Georgia				5, 940	5, 940
Louisiana	25, 000		1, 000		26, 000
Mississippi	300, 000				300, 000
North Carolina			60, 460	10, 000	70, 460
Oklahoma				21, 000	21, 000
South Carolina				[8] 3, 500	3, 500
Texas				50, 000	50, 000
Total	595, 000		61, 460	90, 440	746, 900
Central:					
Illinois			[9] 7, 160		7, 160
Indiana			[10] 21, 979		21, 979
Kentucky				[11] 16, 700	16, 700
Missouri	[12] 40, 000				40, 000
Ohio			[7] 10, 400		10, 400
Total	40, 000		39, 539	16, 700	96, 239
Lake:					
Michigan	12, 000	50, 000			62, 000
Minnesota	1, 230, 000				1, 230, 000
Wisconsin	192, 000		65, 000		257, 000
Total	1, 434, 000	50, 000	65, 000		1, 549, 000
North Rocky Mountain:					
Idaho	[13] 958, 000				958, 000
Montana	[14] 236, 000				236, 000
Total	1, 194, 000				1, 194, 000

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[1] Exclusive of an estimated area of about 11,700,000 acres of tax-reverted land, mostly in the South region, the status of which is very unstable and uncertain, except for 1,250,000 acres in Michigan which is definitely in State hands.

[2] No lands reported for Arkansas, Florida, and Virginia in the South region; Iowa, Kansas, Nebraska, Tennessee, and West Virginia in the Central region; North Dakota in the Lake region; and Nevada in the South Rocky Mountain region.

[3] State institution lands, Indian lands, etc.

[4] These are lands in unorganized towns held in trust by the State for school purposes, until such time as the towns may become organized.

[5] Incomplete.

[6] 80 percent forested.

[7] State game reserve lands.

[8] State penal institutions.

[9] In fish hatcheries, game farms, game refuges, only partly forested.

[10] State institution lands, 3,500 acres; game preserves, 18,479 acres.

[11] Game refuges, 1,700 acres, and forest property of the agricultural college, 15,000 acres.

[12] State university land; possibly 10,000 to 20,000 acres of school land in counties.

[13] Policy is to manage all forest land as permanent properties. Land alone is rarely worth statutory minimum price of $10 per acre.

[14] Forested State land is not subject to sale. Timber can be sold.

TABLE 9.—*State-owned forest land not under administration as State forests and parks, by regions and States, 1932*—Continued

Region and State [2]	Unreserved Federal grant lands	Lands acquired by— Exchange	Purchase and gift	Other lands	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
South Rocky Mountain:					
Arizona	[15] 32, 000				32, 000
Colorado	154, 390	(16)	1, 610		156, 000
Nevada	2, 000				2, 000
New Mexico	[17] 121, 000				121, 000
South Dakota				11, 000	11, 000
Utah	55, 000				55, 000
Wyoming [18]	120, 000				120, 000
Total	484, 390		1, 610	11, 000	497, 000
Pacific coast:					
California	14, 463				14, 463
Oregon	33, 000				33, 000
Washington	826, 925	403, 243	17, 832		1, 248, 000
Total	874, 388	403, 243	17, 832		1, 295, 463

[15] To be retained by State and managed by U.S. Forest Service. Includes acreage of commercial saw timber only.

[16] Prospect of exchange with Federal Government for a State forest of 75,000 acres.

[17] Managed by U.S. Forest Service. Includes acreage of commercial saw timber only.

[18] State not interested in State forests or forestry.

TABLE 10.—*State-owned forest land compared with commercial forest land in all ownerships 1932*

Region and State	Area of commercial forest land in all ownerships	State-owned [1] Under administration as State forests and State parks	Other	Total	Ratio to commercial forest area of: Area under administration as State forests and parks	Total forest area owned by State
	Acres	*Acres*	*Acres*	*Acres*	*Percent*	*Percent*
United States total	494, 898, 000	7, 078, 058	6, 140, 106	13, 218, 164	[3] 1. 42	[3] 2. 66
New England:						
Connecticut	1, 582, 000	70, 960	2, 428	73, 388	4. 49	4. 64
Maine	14, 490, 000	5, 760	[2] 400, 187	405, 947	. 04	2. 80
Massachusetts	3, 255, 000	120, 000	12, 500	132, 500	3. 69	4. 07
New Hampshire	4, 435, 000	32, 754	1, 533	34, 287	. 74	. 77
Rhode Island	279, 000	3, 768	500	4, 268	1. 35	1. 53
Vermont	3, 232, 000	42, 308	200	42, 508	1. 31	1. 32
Total	27, 273, 000	275, 550	417, 348	692, 898	1. 01	2. 54
Middle Atlantic:						
Delaware	320, 000	51	91	142	. 02	. 04
Maryland	2, 168, 000	50, 310	5, 246	55, 556	2. 32	2. 56
New Jersey	1, 973, 000	61, 449	4, 291	65, 740	3. 11	3. 33
New York	9, 593, 000	2, 448, 254	43, 288	2, 491, 542	25. 52	25 97
Pennsylvania	13, 085, 000	1, 579, 809	291, 240	1, 871, 049	12. 07	14. 30
Total	27, 139, 000	4, 139, 873	344, 156	4, 484, 029	15. 25	16. 52

[1] Exclusive of an estimated area of about 11,700,000 acres of tax-reverted land, mostly in the South region the status of which is very unstable and uncertain, except for 1,250,000 acres in Michigan which is definitely in State hands.

[2] Of this total, 400,000 acres are lands in unorganized towns held in trust by the State for school purposes, until such time as the towns may become organized.

[3] Forest Service estimates on the area of forest land in the United States do not include Kansas and Nebraska. These percentages are based on an estimated area of a million acres of forest land in each of these States.

TABLE 10.—*State-owned forest land compared with commercial forest land in all ownerships 1932*—Continued

Region and State	Area of commercial forest land in all ownerships	State-owned			Ratio to commercial forest area of:	
		Under administration as State forests and State parks	Other	Total	Area under administration as State forests and parks	Total forest area owned by State
South:	*Acres*	*Acres*	*Acres*	*Acres*	*Percent*	*Percent*
Alabama	21, 680, 000	9, 326	270, 000	279, 326	. 04	1. 29
Arkansas	22, 000, 000	1, 048		1, 048	. 005	. 005
Florida	23, 600, 000	4, 000		4, 000	. 02	. 02
Georgia	22, 872, 000	344	5, 940	6, 284	. 002	. 03
Louisiana	17, 922, 000	6, 206	26, 000	32, 206	. 03	. 18
Mississippi	18, 293, 000	23, 000	300, 000	323, 000	. 13	1. 77
North Carolina	20, 216, 000	1, 464	70, 460	71, 924	. 007	. 36
Oklahoma	4, 279, 000		21, 000	21, 000	. 0	. 49
South Carolina	12, 415, 000		3, 500	3, 500	. 0	. 03
Texas	12, 624, 000	10, 565	50, 000	60, 565	. 08	. 48
Virginia	14, 857, 000	588		588	. 004	. 004
Total	190, 758, 000	56, 541	746, 900	803, 441	. 03	. 42
Central:						
Illinois	3, 196, 000	6, 105	7, 160	13, 265	. 19	. 42
Indiana	3, 438, 000	34, 035	21, 979	56, 014	. 99	1. 63
Iowa	2, 358, 000	7, 031		7, 031	. 30	. 30
Kansas	(2)	1, 318		1, 318	[3] . 13	[3] . 13
Kentucky	10, 296, 000	8, 075	16, 700	24, 775	. 08	. 24
Missouri	16, 500, 000	41, 133	40, 000	81, 133	. 25	. 49
Nebraska	(3)	2, 661		2, 661	[3] . 26	[3] . 27
Ohio	4, 651, 000	57, 479	10, 400	67, 879	1. 24	1. 46
Tennessee	14, 041, 000	39		39	. 0003	. 0003
West Virginia	9, 769, 000	15, 620		15, 620	. 16	. 16
Total	64, 249, 000	173, 496	96, 239	269, 735	[3] . 26	[3] . 41
Lake:						
Michigan	19, 000, 000	809, 050	62, 000	871, 050	4. 26	4. 58
Minnesota	20, 200, 000	1, 069, 095	1, 230, 000	2, 299, 095	5. 29	11. 38
North Dakota	495, 000					
Wisconsin	16, 200, 000	122, 652	257, 000	379, 652	. 76	2. 34
Total	55, 895, 000	2, 000, 797	1, 549, 000	3, 549, 797	3. 58	6. 35
North Rocky Mountain:						
Idaho	17, 464, 000	5, 505	958, 000	963, 505	. 03	5. 52
Montana	14, 865, 000	203, 000	236, 000	439, 000	1. 37	2. 95
Total	32, 329, 000	208, 505	1, 194, 000	1, 402, 505	. 64	4. 34
South Rocky Mountain:						
Arizona	3, 651, 000		32, 000	32, 000		. 88
Colorado	12, 516, 000		156, 000	156, 000		1. 25
Nevada	377, 000		2, 000	2, 000		. 53
New Mexico	3, 806, 000		121, 000	121, 000		3. 18
South Dakota	1, 284, 000	61, 000	11, 000	72, 000	4. 75	5. 61
Utah	3, 348, 000		55, 000	55, 000		1. 64
Wyoming	5, 588, 000		120, 000	120, 000		2. 15
Total	30, 570, 000	61, 000	497, 000	558, 000	. 20	1. 83
Pacific coast:						
California	17, 538, 000	46, 426	14, 463	60, 889	. 26	. 35
Oregon	28, 838, 000	70, 113	33, 000	103, 113	. 24	. 36
Washington	20, 309, 000	45, 757	1, 248, 000	1, 293, 757	. 23	6. 37
Total	66, 685, 000	162, 296	1, 295, 463	1, 457, 759	. 24	2. 19

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[2] Of this total, 400,000 acres are lands in unorganized towns held in trust by the State for school purposes, until such time as the towns may become organized.

[3] Forest Service estimates on the area of forest land in the United States do not include Kansas and Nebraska. These percentages are based on an estimated area of a million acres of forest land in each of these States.

Table 8 shows that the State forest lands which have been set aside for forest and park purposes and placed under some degree of organized administration for these purposes aggregate 7,078,058 acres, out of a total of 13,218,164 acres of forest lands owned by the States. The latter total is equal to 2.66 percent of the entire commercial forest area of the States. It must be said, however, that the amount of land actually in State ownership is in many cases undetermined, and in some States highly conjectural. State lands comprise in the main granted lands, tax-reverted lands, and lands acquired through gift, exchange, or purchase. Granted lands are seldom specifically located by the law upon its enactment. The States must usually obtain them through selection to satisfy quantity or indemnity grants, or through identification when the public lands survey reaches them (as in the case of school lands), or through establishment of their character, as in the case of swamp lands. States which still hold title or unsatisfied claims to substantial amounts of granted public lands are very likely not to know just how much forest land they have or will have. Still more is this true for tax-reverted lands. The law and procedure relating to redemption and resale of delinquent tax lands, to the forfeiture of title, and to the taking over of title by the State or county vary greatly. Except in the relatively few States which have definitely embarked upon a policy designed to discover, segregate, and place under permanent public administration in suitable units tax-reverting lands chiefly valuable for forest purposes, both the extent and the status of these lands are frequently indeterminate. They form a twilight zone between State or county ownership and private ownership, of very large aggregate proportions. With the pronounced present trend toward further abandonment of cut-over lands by private owners, this zone is broadening.

The subject of the breakdown of private ownership is dealt with in a separate section of this report. No attempt is there made to indicate the acreage of tax-forfeited land in all the States, nor to estimate its total amount. The whole field is one of uncertainties. In only a relatively few of the States in which tax forfeiture is extensive is precise knowledge of the situation available. In 29 States title reverts to the counties or towns, with no central source of information on tax delinquency. Not all of the remaining States know accurately the acreage of lands which have reached the stage of title forfeiture, and the provisions and administration of the State laws relating to forfeiture are often so lenient that a clear title is not obtained by the State for a long period, if at all.

In fact, recognition of the necessity for any other course than a temporary taking over of title as a means of passing the land back into private ownership has in most States not begun. The whole procedure is nearly everywhere based on the assumption that either through redemption by the former owner or through sale to a new owner the land can be got back on the tax rolls, and that of course it should be got back as the only way to provide for its productive use. The result of all this is that land abandonment through nonpayment of taxes has built up and is in process of further building up an aggregate of many millions of acres of "no man's land." The former owner has quit, and all efforts to keep the land in permanent private ownership will probably be unavailing, yet the State either has not taken over the title or, if it has, has done so only as a supposed means of putting a new owner in secure possession. To afford some indication of the dimensions of the forest-land problem with which State policies must deal, one way or another, estimates were sought of the amounts of forest land in the several States which have been tax delinquent for the period fixed by law as involving the loss of title. The estimates showed a total of 11,700,000 acres.

Obviously, these figures can be considered as at most only very broadly indicative of the actual conditions. Much of the acreage may be taken back by the former owners, or at least temporarily got rid of through tax sales to new owners. On the other hand, wherever tax delinquency is widespread a strong presumption is created that a substantial increase in the amount of involuntary public ownership is impending. As an index of the general situation, the figures cited are probably overconservative; but as an indication of the particular situation at the present time in each individual State they would be, if distributed, very uneven and in some cases of very dubious value. Consequently, in tabulating the areas of State-owned forest land, tax-reverted lands which have not been incorporated in definite units of administration as State forests or State parks are uniformly not included. The fact remains that the States do actually own a very much greater amount of forest land than is shown. In the case of Michigan, where accurate data are a matter of record, a footnote indicates that the State holds title to 1,250,000 acres of tax-reverted lands in addition to the 871,050 acres shown in the body of the table as the State's total ownership.

STATE GAME REFUGES AND PUBLIC HUNTING GROUNDS

The tables do not show to what extent State-owned forest lands are under administration for other purposes than State forests and State parks. Some millions of acres are included in reservations for game refuges and public hunting grounds, but these largely embrace lands also under reservation as State forests and State parks. Further, the lands are by no means always forest lands. On the other hand, this form of land use so overlaps and dovetails with forest and park administration that it needs to be brought into the picture.

One of the purposes served by State forests is wild-life conservation and the provision of public hunting grounds. Wild life is in part a forest product. To prevent the extermination of valuable wild life and maintain a good supply of game, fish, and fur-bearers, reliance was at first placed on restrictive laws creating closed seasons, imposing bag limits, and the like. Gradually it came to be seen that more was needed than the enactment and enforcement of inflexible laws. Out of this came the conception of wild-life management.

Wild life is a renewable resource, like forests. It is a usable resource, in three principal ways. It may be enjoyed, without disturbance, as one of the attractions of the open; it may be utilized through hunting and fishing, as a means for recreational sport; and it may furnish food and fur. Its main importance as a source of food supply was in the early days of settlement and for the still earlier period of pioneer exploration, when the oncoming white men had to live off the country; in those days abundance of game sometimes determined where the settlers preferred to locate, more than the character of the soil. Under present conditions the food value of game is incidental. Its quantity is subject to great fluctuation unless there is careful and skillful control of the various factors on which depend the abundance of any particular species of wild life within a particular area. Wild-life administration is the exercise of this control.

Sufficient food, suitable cover, freedom from molestation or disturbance, especially in the breeding season, and a check on losses beyond the number that will be replaced by the natural increase are the principal requirements for maintaining valuable wild life in reasonable abundance. Good game management calls for seeing to it that any given area is neither understocked nor overstocked. If understocked, full use of the potentialities of the area is not made. If overstocked, the wild-life population suffers in the same ways as does an overcrowded human population. Starvation and disease may then make terrible inroads upon the number, cutting it back to a point far below the normal for the area. To permit the conditions which produce overstocking is inhumane. Wise game administration aims at maintaining the right balance; and this necessitates some means of disposing of the surplus production as the optimum conditions are reached.

State forests have proved of great value as a means of keeping up the supply of game, fish, and fur-bearing animals. The maintenance of the native wild-life resource has been in some States one of the important objectives of the State forest policy. In furtherance of this purpose, many States have made portions of their forests game refuges, and some forest lands have been and are being acquired primarily or solely as game refuges or public hunting grounds. Several States use for this purpose receipts from game and fish licenses.

In short, State administration of forest lands includes the administration of an undetermined but by no means negligible acreage as an adjunct to game management. The desire of sportsmen for public hunting grounds and game refuges will probably lead to more extensive acquisitions by the States of lands with these ends in view. Where the lands are suited to use for other forest purposes consistently with the primary object of increasing the game supply or the area open to the public for hunting, presumably their dual use will be provided for. In any event, forest lands acquired or set aside for game production deserve to be rated along with State forests and State parks, as lands held under the same broad policy of permanent State ownership and administration for the service of public needs.

THE DISTINCTION BETWEEN STATE FORESTS AND STATE PARKS

Federal policy and administrative organization establish a clear line of demarcation between national forests and national parks. The establishment of this distinction, however, has been a gradual process. Many people still do not recognize it. The essence of the Federal distinction is that national-forest administration aims at a coordinated use of the various resources, material and immaterial, which each area affords. The public values involved are appraised and weighed one against another, to the end that through carefully planned adjustments of one form of use to other forms the greatest net total of public benefits may be realized. In application, this principle may mean that limited areas are devoted to a single exclusive use, because that use is the most important and in the particular case involved cannot be dovetailed in with other forest uses satisfactorily. National parks, however, are extensive areas where the immaterial values are of such exceptional quality and supreme importance that utilization of the land for the production of commodities, such as lumber or livestock products, should not be considered.

Some States make a similar distinction between "parks" and "forests." In other States the terminology is misleading. Where the distinction is sharply drawn, the administration of the State parks and State forests may be by the same organization, or by separate units in the same department, or by entirely disassociated units. Popular thought in the East tends to run to the conception of all public forests as maintained primarily for park purposes, and this adds to the confusion. Further, the objectives of the States for the areas designed to serve the purpose of timber production generally emphasize strongly what may be called the park conception and frequently tend to relegate to a secondary place, for the time being at least, provision for making use of and increasing the valuable timber growth. Thus there are elements of artificiality in the division set up between State parks and State forests. Functionally they often tend to merge. Nevertheless, it is believed preferable in the present discussion to distinguish them.

STATE FOREST LAND ADMINISTRATION IN THE NORTHWEST

Another line of demarcation which involves some uncertainty is that between State forests and other lands in State ownership. A twilight zone has been created by State action of different kinds, that has given some State-owned forest lands an in-between status. A striking example of this is in three States of the Northwest.

By legislative enactment Montana has placed 200,000 acres of specifically designated land in definite administrative units not subject to alienation, but to be held permanently by the State and administered for purposes of timber production and watershed protection. In addition, the law prescribes that all lands of the State "principally valuable for the timber that is on them, or for the growing of timber, or for watershed protection" are not to be disposed of; and any timber cut from them must be taken in accordance with prescriptions to assure continued timber production and water conservation. The State system of fire protection covers all these lands. The major difference, and indeed practically the only difference, between the lands included in the specifically designated State forests and those not so included is that the latter are more scattered and may require considerable blocking up to assemble areas of sufficient solidity for reasonably economical permanent administration. In blocking up, a good many isolated and scattered areas may eventually prove to be unsuitably located for permanent State management. Yet it may be claimed, and with reason, that the character of the oversight exercised by the State and the law prohibiting disposal of the lands give them better title to the name of State forests than some areas so classed elsewhere. The area of these "twilight zone" lands in Montana totals 236,000 acres.

Idaho has approximately 964,000 acres of State forest land, of which somewhat more than one-half is customarily classified as in State forests. These latter lands are well blocked up, having been obtained by the State through an exchange of its school land sections scattered in the national forests for a solid body of timberland formerly a part of the national-forest area. The State is not selling these lands, and when it sells timber from them it does so under stipulations designed to assure future timber crops. The weakness is that the whole system of administration has no other support than the choice of the State land administrative agency. The officers constituting the land board could upset the policy at any time, should they think it in the best interest of the State to do so. For this reason Idaho is counted in the present report as having no State forests. Yet, if a guess may be hazarded, these lands, already under forestry administration, will presumably continue to be so administered and will sooner or later be given the status of State forests established by law.

In Washington there are nearly 1,300,000 acres of State-owned forest land, of which more than 1,000,000 acres is reserved and usually classed as included in State forests. But this classification is decidedly open to challenge. The State has a law somewhat like that of Montana, up to a certain point. While it makes no mention of watershed values and sets up no specifically designated areas, it provides that lands acquired or designated by the State forest board as State forest lands shall be forever reserved from sale. When timber is cut from them, it must be in conformity with the requirements of that board to insure natural reforestation. The State has about 403,000 acres of forest land in solid blocks obtained partly through an exchange similar to that in Idaho, partly through the exercise of rights of selection. In addition, various officials are required to report yearly to the State forest board any State or private logged-off or deforested lands coming to their notice, which they regard as suitable for State forest lands or reforestation; and the Commissioner of Public Lands may classify and reserve logged-off State lands suitable for reforestation, whereupon it becomes the duty of the Director of Conservation and Development to protect and reforest them. Although, as said above, the State now has under reservation more than 1,000,000 acres, up to the present time the State forest board has designated as State forests only 45,757 acres. Yet with its more than 400,000 acres of blocked-up lands obtained through Federal exchange, with its still greater area of other forest lands that have been reserved for reforestation, and with a definite State policy so clearly formulated legislatively, Washington has gone much farther than would appear from the bare statement of the acreage embraced in definite units of administration. Nowhere else are the drawbacks of a sharp division between "State forests" and "other State-owned forest lands" so well illustrated. Whatever the scheme of classification, if it does not bring into view the extensive twilight zone of lands not actually under administration as State forests but more or less definitely held with a view to their future use for this purpose, its results carry misleading implications.

In these three Northwestern States, each owning large acreages of forest lands which occupy a kind of halfway status between organized, permanent State forests and State lands awaiting a purchaser, the forest holdings are made up principally of lands which have never been in private ownership, but came into the possession of the States through Federal grants. The "twilight zone" condition is, however, not confined to States which became forest owners through grants from the old public domain. It is found in some of the Eastern States which have become possessed of forest lands under the process which is creating the "new public domain," made up of abandoned private holdings. Michigan, Wisconsin, and Minnesota are outstanding examples.

STATE FOREST LAND ADMINISTRATION IN THE LAKE STATES

Except for the prairie portion of northwestern Minnesota, in all three of these States a large fraction of the northern portions cannot be successfully used for agriculture. Because of the magnificant stands of virgin timber, the land became a rich prize for the lumbermen, and for several decades the Lake States led the country in lumber production. It was generally assumed that the cut-over areas would soon be converted into prosperous farms; but the hope of a flourishing general agricultural development in succession to the great pineries proved delusive. Great portions of the stump lands, in spite of vigorous efforts to dispose of them to settlers, either remained unsold or were cleared only to be abandoned after years of wasted effort, save where the soil proved to be of exceptional quality or where the occupant, for lack of courage or initiative to try again elsewhere, clung to his submarginal acres and eked out a scanty livelihood as best he might. Now, belatedly, it is realized that the best hope of prosperity for the country of the "Great North Woods" is to restore the nonagricultural and submarginal agricultural lands to forest production, and that this will necessitate extensive public ownership and reforestation, at a heavy expense for years.

Some of the sparsely settled northern counties are bankrupt, and many are a burden on their State, drawing much more from the treasury in the form of contributions toward the cost of local government than they return. At the same time the tax rate on such property as remains to be taxed in the poorer counties is as a rule very high, and tending to go higher. Tax delinquency has reached such proportions that the problem of the "new public domain" cannot possibly be ignored. Its magnitude is illustrated by the fact that from 18 million to 20 million acres of forest land in the Lake States is tax delinquent and at least in major part virtually abandoned by its owners, with a rate of increase in the amount which bids fair in another decade, if it continues undiminished, to place in public ownership well on toward one half of the forest area of the region.

Already Michigan has, in addition to several hundred thousand acres which have been included in her present State forests, 1,250,000 acres of tax-forfeited lands, with perhaps 4 million acres more that is at some stage of tax-delinquency. In Wisconsin tax-forfeited lands pass not to the State but to the county; the amount is uncertain, but according to some estimates seems to approach 1,900,000 acres with more than 3 million acres addition estimated to be tax delinquent. In Minnesota before the close of 1933 the tax-forfeited lands will total 4 million acres. The reverting lands, naturally, have been stripped of their salable timber and in large part are idle, fire-devastated waste. State policies designed to work out the permanent retention of large aggregates of these lands for permanent public forests have set up the Lake States twilight zone of lands which are being more or less definitely held with a view to this form of use, but which are not as yet under actual administration nor as yet sufficiently blocked up, oftentimes, to provide practicable units of administration.

The first of the three States to adopt a policy looking to the reservation and administration for forest purposes of tax-reverted lands was Michigan, with a law enacted in 1909. Some years previously more than a million acres of tax-forfeited lands had been in the hands of the State but had largely gone back, at least temporarily, into private ownership through their purchase by speculators, who had sold them off as farmlands to unwary victims. A public domain commission was therefore created to segregate the lands really suited to agriculture and set aside the rest for forestry purposes. The reservation of not less than 200,000 acres was made mandatory by the law. But locally, public sentiment was adverse to heavy withdrawals from private acquisition, preferring that the land should be open to homesteading in the hope of more settlers; and the commission limited itself to reserving a total of 235,194 acres in small bodies scattered through 54 counties. Gradually, however, the principle of classification has come to be generally accepted in Michigan. A law passed in 1929 requires that all tax-reverted lands shall be turned over to the conservation commission, with a view to their consolidation into State forests or other public reservations unless they are found suitable for homesteading.

At the present time the State has 12 established State forest units, with a gross area of approximately 1,400,000 acres. Within these units the State owns or has in process of acquisition 863,113 acres, and its ownership has been increased through exchanges, purchases, and donations as well as through tax reversion. But the prospective burden which will be imposed upon the State if it carries through the policy of reforesting, protecting, and otherwise caring for the great areas of virtually worthless lands that are in sight is so great that it is a good deal of a question how far to pursue the course marked out. Tax reversion has been adding new lands to the State's holdings at the rate of a quarter of a million acres a year, and this rate will probably be greatly accelerated in the immediate future through the effects of the business depression. In 1931, the last full year for which figures are at hand, 32,040 acres of land within the State forests were reforested through planting, while the nonrestocking land in these forests is estimated to aggregate 220,000 acres and the poorly restocking an additional 204,000 acres. The depression has halted expenditures for further planting and land purchases. There is doubt in some quarters as to whether the results of reforestation will justify the cost, at least on the lands of poorest quality; there has been considerable hesitancy about turning over to the conservation commission, as the law requires, lands which might be got back on the tax rolls through resale; and the commission itself has been hesitant to carry through the policy of placing under forestry administration to the fullest extent the lands over which it has jurisdiction, lest the approriations necessary for the administration of more State forests may not be forthcoming. The acreage of tax-reverted lands which the commission is how holding, with its disposition not as yet definitely determined, is much greater than the acreage of State-owned land within the established forests.

Some of the tax-reverted lands have been reserved and placed under administration as State parks and State game refuges; but the aggregate required for these purposes does not materially alter the situation. In the 1929–30 biennial report of the Michigan Department of Conservation, the State forester, after pointing out that the total area in forests, parks, and game refuges comprised only 39 percent of the entire amount of land held by the State, went on to say:

> Compared to the millions of acres of similar lands within our borders on which the crop must be timber or nothing, it is but an insignificant part. Obviously it is so nearly a negligible quantity with respect to the whole that unless enormously expanded it can have no appreciable effect toward the solution of the situation in general. This condition is neither local nor confined to present State lands, but involves a vastly greater acreage, more or less State-wide. It is variously estimated that there are between 10 million and 20 million acres of just such land as has reverted to the State that are ill-adapted for anything but tree growth. A conservative figure would be 15 million acres. Whatever the area, it is of such magnitude that it constitutes the most important task in conservation confronting Michigan today. It is a big problem which must be met in a big way sooner or later, and the sooner the better. Michigan must think of State forests in terms of millions of acres instead of thousands.

This enormous twilight zone of artificially created near-desert, which will not stay in private ownership, which the people of the State have through their legislature authorized their administrative officers to take charge of and place in State forests and similar reservations, but which can be restored to productiveness only through very considerable expenditures that must extend over many years before substantial money returns can be looked for, creates the outstanding problem of forestry and land utilization in the Lake States. Only to a minor degree does the Federal policy of acquisition for the building up of national forest lighten the prospective burden on the States. In view of the complexity as well as the magnitude of the unsolved problem of what the States should, can, and will do with their new public domain as it enlarges, definite assumptions regarding the extent to which the lands now tax-reverted are on the way to being placed under administration would be premature.

In Wisconsin the problem presented by tax-reverting lands is given a somewhat different form by the fact that title passes to the counties. In consequence the State has adopted a policy of financial aid to encourage county forests. Wisconsin's county forest system is discussed in the section of this report entitled "Community Forests." The point to be noted here is that the development of county forests is in Wisconsin a part of the program adopted by the State for placing in public forests lands abandoned by private owners as not worth paying taxes on. Wisconsin has in State forests 111,100 acres, with 320,000 acres more in process of acquisition, and in county forests 460,521 acres. The two must be considered together if the effort that the State is making to meet its forest land situation is to be fairly judged.

Of the area in county forests 292,981 acres, or 64 percent, is not under actual management. In addition, the counties are said to own 1,440,000 acres of forest land which has not been placed in county forests. The law authorizing them is still new. Since for every acre included in a county forest the county draws from the State treasury 10 cents annually and the township 10 cents more, a strong incentive to give the lands the designation is set up. But unless they are to be handled in accordance with the practices of technical forestry, designating them county forests does not convert them into productive land. If the present legislation and present trends in tax delinquency are continued for 10 years, the county holdings are likely to be increased by possibly 6 million acres. Here again, the economic burden which must be assumed by some agency if all the lands are to be put into an actually productive condition promises to be staggering. It remains to be seen just what plan of administration will eventually be worked out in Wisconsin, and how extensive will be its application; but it is possible to attach more significance to the figures of area of the present combined State and county forests than they perhaps deserve. That Wisconsin is now very much alive to the formidable dimensions and serious character of the land use and forest problem which has to be faced is quite true, and that a great change in the situation will be worked out seems unquestionable; but compared with the State forest systems of the few States in which the enterprise has become firmly established in public approval and put on a good working basis, the present showing of Wisconsin in provision for public forest administration is mostly a showing on paper.

Minnesota also has awakened to the necessity of meeting in a large way the land use problem created by temporary private ownership of forest lands for the sake of the accumulated timber values, with its aftermath of land surrender when the merchantable stand has been cut off. The situation in Minnesota is made different from that in either Michigan or Wisconsin by the fact that Minnesota still holds a large aggregate of timberlands received under the Federal land grants. While Michigan has only about 12,000 acres of forest lands left of the original granted lands, and Wisconsin about 190,000 acres, Minnesota has more than 2 million acres. In addition, under the provisions of a law enacted in 1927 to afford a clear title to lands on which taxes have not been paid for 5 years, some 4 million acres are expected from this source in 1933. Thus there is a combination in Minnesota of the situation that exists in the other Lake States with respect to reverting cut-over lands and of that which exists in Montana, Idaho, and Washington with respect to forest lands derived from Federal grants. Like the three Western States, Minnesota has constitutional restrictions upon the sale of the granted lands which have operated to hold in her possession a very substantial part of her originally more than 8 million acres of granted lands of all kinds.

Although Minnesota passed the first law looking to the establishment of forest reservations in 1899 and shortly afterward received, through a private donation and a special Federal grant, a few thousand acres dedicated to this purpose, and although following a constitutional amendment in 1914 400,000 acres were given the status of State forests, the actual organization of a system of State forests as going enterprises is still in the formative stage. Prior to 1931, 13 units with a gross area of more than 1 million acres but embracing a little less than 500,000 acres of State-owned lands received designation as State forests. No development work has been undertaken on these units, and no local organization created primarily to take charge of and care for them has been set up. Instead, the State's holdings within them are administered and protected, as an incident to other duties, by the district fire wardens and rangers of the organization provided for fire control on forest lands in all ownerships. This course is necessitated by the fact that no specific financial provision for the administration of State forests has yet been made. In 1931 the legislature designated as State forests certain other areas, embracing an additional half million acres of State land, but these are as yet only paper forests.

From tax-reverting cut-over lands the Conservation Department's program aims at blocking up an approximate total of 4 million acres of State forests in the next 10 years. Comprehensive legislation has been enacted looking to a determination of the form of use to which are best adapted all the lands now in or which may come into State ownership, with provision for placing in reservations for various purposes those lands calling for permanent public ownership and administration in order to give them their highest usefulness; and there is provision also for acquisition of private lands which should be consolidated with the State's holdings. In line with this legislation, a land classification survey is covering the areas within and adjoining the State forest boundaries, and has already gone over nearly 2 million acres to obtain a factual basis on which to rest acquisition and management programs. Thus the forest and land use problem is being aggressively and constructively attacked. On the other hand, the situation presents some uncertainties.

A possible difficulty in carrying out the constructive policy upon which the State has made so promising a start arises from the fact that neither with respect to the lands received through Federal grant nor with respect to those received through tax forfeiture is the State free from restricting obligations. The granted lands are lands held by the State in trust, for specific purposes. The tax-reverted lands likewise carry an obligation of trusteeship for the various taxing units in the proportion of the unpaid taxes, with the State's equity in them usually less than 10 percent of the whole. There is a considerable inclination among the local county and township officials to feel that under these circumstances the county rather than the State should have the determining voice regarding what disposition shall be made of the land. It remains to be seen what kind of division of responsibilities and what plan for satisfying claims and obligations will be worked out. Most of all, it remains to be seen what the public sentiment of the State will permanently sustain and demand and how successful the State will be in obtaining the continuity and stability of policy and the competent conduct of the enterprise necessary for its success.

That a high standard of competence as well as integrity are fundamental to making the essentially business enterprise of forest management anywhere a success, and that no business, public or private, can be expected to succeed if it cannot be run solely with a view to the most efficient conduct of the enterprise, are matters that have already been repeatedly brought out. Nepotism in a private concern endangers the invested capital; and public administration equally requires freedom from the dry rot of political motive or control for narrowly political ends. It is all a question of developing high standards of efficiency in the field of State government and providing the necessary stability when the enterprise is in competent hands.

Hitherto, State governments taken as a whole have not been conspicuous for their success in developing the function of public service as applied to difficult, constructive tasks. The situation of the Lake States in this respect is on all fours with that of every other State in which public forest administration may be undertaken as a State enterprise. It is the same situation as that which for a good while made the success of the Federal forest reserve policy uncertain. Success in that came through a happy combination of very unusual circumstances, of which one was the establishment on a firm foundation in the Federal establishment of the merit system for the Civil Service.

REGIONAL CONCENTRATION OF STATE FORESTS

Of the 7,078,058 acres embraced in organized State forests and parks 89 percent is in the North and Middle Atlantic States and the Lake States. New England has 276,000 acres of forest in her State forests and parks, New York has about 2,450,000 acres, Pennsylvania about 1,600,000 acres, New Jersey 61,000 acres, Maryland, 50,000, and the three Lake States 2 million acres not including Wisconsin's 460,000 acres of county forests, with large further increases in prospect under legislation already enacted. In the far Northwest, Montana, Idaho, and Washington make up another group of States in which there are extensive holdings of forest lands under more or less definite reservation (or in Idaho's case under actual operation though without any expressed legislative policy of management or permanent ownership) for State forest purposes. These three States together own 2,700,000 acres of forest land, of which not quite three fourths take their place in the "twilight zone" between State forests and "other State-owned forest land." Elsewhere than in these three groups of States, one along the Atlantic coast, one about the Great Lakes, and one in the Pacific Northwest, State forests have scarcely begun to appear on the map. Within these three groups of States is the ownership of 86 percent of all the State-owned forest land in the country.

This high degree of concentration of State forests suggests at once some important questions. Why have not States in other regions embarked on programs of extensive forest ownership and administration? Are they likely to fall into line shortly, or must any large increase in the area of public forests, if a large increase is necessary, depend upon Federal action either through a greatly expanded program of acquisition for national forests or through aid to the States, to enable or induce them to acquire the lands themselves?

In attempting to get at the facts which may throw light on these questions it is essential to bear in mind the very different situations in the western half and in the eastern half of the country. One great difference is that of the entire western commercial forest area 62 percent is federally owned, or is managed by the Federal Government as trustee on behalf of Indians, and 53 percent is in national forests, as against 2 percent in Federal ownership or trusteeship and 1.7 percent in national forests in the East. Many of the public needs in response to which eastern State forests are being built up, to the extent that they are being built up, are in large measure taken care of in the western country by the national-forest system. It is true that in the West land use problems of large proportions are beginning to appear in several States, as the timberlands in private ownership are converted into cut-over lands which the owners may no longer wish to retain. Even in meeting this problem, however, the Western States are appreciably aided by the possibility in many instances of adding these cut-over lands to the national forests.

What has been done by the Western States hitherto toward building up State forests has been due primarily not to a felt need for State ownership leading to a policy of acquisition, but to the Federal land grants. In most States the policy, practically from the time that the State governments were set up, has been to dispose of the granted lands as fast as there was a sufficient demand for them to permit them to be sold off. In a majority of cases the States have disposed of most of their granted forest lands. It should be remembered that the grants of public domain lands were made for specific purposes and that the States, in receiving them, were in the position of trustees. School and institutional grants, for example, were in the nature of endowments. As administrators of trusts the States were bound to consider first of all the best interests of the beneficiaries of the trust. The State educational institutions and public school systems were the leading beneficiaries, and by the sale of the lands and investment of the proceeds dependable sources of revenue for these institutions were created. To hold the lands and put them under administration for the sake of general public benefits which might thus be realized, or to engage in enterprises of forest management of uncertain financial outcome, would not have been in accord with the obligations of trusteeship for specific beneficiaries.

Several of the States, however, introduced into their constitutions safeguards against the disposal of granted lands by the State land authorities at too low prices. The effect of these restrictions has been to keep relatively large areas in the hands of the States having the limitations, for lack of purchasers willing to pay the necessary price. Idaho and Washington are examples. North Dakota, New Mexico, and Arizona are similarly restricted under the terms of their respective enabling acts.

Where States had rights under their land grants to school sections scattered through the national forests, or right of selection based on the school sections, the Federal Government has if possible negotiated exchanges with a view to enabling the States to obtain lands of equal value outside the forests. Under the exchange agreements, the States have been given an opportunity to obtain in lieu of their school lands solid blocks of land eliminated from the forests to permit the States to file on them. In this way the following States have received lands suitable for administration by them as State forests or parks, in the amounts shown:

State:	*Acres*	State—Continued	*Acres*
California	8, 973	Oregon	68, 666
Idaho	282, 997	South Dakota	60, 150
Montana	106, 607	Washington	405, 942
Nebraska	8, 959		

At the present time exchanges are under negotiation with Colorado and New Mexico, by which the first State will receive approximately 100,000 acres of blocked up land and the second 286,757 acres.

The acts granting statehood to Arizona and New Mexico also granted large areas of public lands for common-school purposes, but provided that where the lands so granted were within national forests the States would not acquire title thereto unless or until the lands were eliminated from the national forests. But the acts specified that pending that time there should be paid annually to each State shares of the gross revenues from the national forests proportionate to the ratio between the lands granted to the State and the total net area of national-forest lands within the State. The States, however, were privileged to use the granted lands as base for lieu selections of unreserved public lands. New Mexico has exercised this privilege so fully that only about 35,000 acres remain in the national forests subject to the rule mentioned; but Arizona largely has preferred to leave her granted lands under national-forest management and has to her credit approximately 1,125,000 acres in that status. Some 30,000 acres of university lands are also administered by the Forest Service for Arizona under cooperative agreement. In New Mexico the State secures technical advice in timber management from the Forest Service, but the agreement does not cover the actual protection and administration of State lands by the Federal agency.

In South Dakota, the State park of 61,000 acres and an additional area included in a State game refuge were obtained through exchange, and California's 9,900-acre State forest is likewise the result of an exchange. In short, the explanation of most of the State forest land administration that has been undertaken or is in prospect in the West is to be found in the fact that because of the presence of the national forests the States were able to convert their school lands into blocked-up areas suitable for enterprises of forestry. They have had the great advantage of being able usually to start with lands on which the original timber was still in place. The few States which remained in possession of more than small remnants of their granted lands are now able to go ahead with undertakings of forest management far different from those that must begin with stripped lands, as in the East. Except in Washington there is nothing as yet to indicate that there is any thought of building up State forests as they are being built up in a few of the Eastern States, to take care of the land use problem created by the breakdown of private ownership.

Neither is it to be expected that extensive enterprises of forest administration are likely to be engaged in soon by many more Eastern States than those which have already made substantial beginnings. It is a very slow process to get such enterprises under way. New York has reached her present position after nearly 50 years of upbuilding; Pennsylvania after 35 years; Connecticut after 30 years; and so on. The Lake States have been moving a long time, but without much progress until they suddenly woke up to an economic and social problem of the first magnitude for them, which could not be ignored. Much depends on the accident of finding the right leadership and a favorable combination of circumstances. Much of the support for State forests in the East has come from those interested in outdoor recreational opportunities. In States of relatively sparse population, rural conditions, and less wealth this form of interest will be much less impelling. Given strong local leadership, there may be seen a really important development of State forest administration for the region of worn-out farms, eroded hillsides, and poor soils that extends north of the Ohio, from Pittsburgh to the Mississippi; but outside of this region and the regions in which are so highly concentrated the State forests at the present time, to expect any really large local movement for the undertaking of land acquisition on an extensive scale would seem to fly in the face of all probability. The necessary motive forces do not seem to be in sight.

COMMUNITY FORESTS

By C. R. Tillotson, District Forest Inspector

In preceding sections, national and State forests have been discussed. The Nation and the States are engaged in a big way in ownership and administration of forest lands. To a much lesser degree the same is true of the smaller political units. Several hundred towns, counties, boroughs, and cities in the United States today own forest land that is set aside for definite purposes and appears destined to remain in public ownership. Ordinarily such lands are called town or municipal forests, or county forests.

TOWN OR MUNICIPAL FORESTS

The town or municipal forests correspond after a fashion to the communal forests of Europe, and in numerous cases owe their origin partly at least to the enthusiasm aroused by glowing accounts of these European forests, how they served as recreation centers and game and bird sanctuaries, how they gave employment to many people, and above all yielded so much revenue from the sale of forest products that local taxes were unnecessary. There are such forests in Europe. The outstanding examples are rather large in size, one or two thousand acres or more, and the population of the fortunate proprietary community is small. That a comparatively large forest area which has been skillfully managed over a long period of years in Europe can support the governmental activities of a sparsely populated commune or municipality is entirely possible. Unfortunately progress up to the present time does not as yet hold much promise of similar developments in the United States in the immediate future at least.

The European commune corresponds closely to the New England town. In the New England States, outside of cities, the town or township is the important local political unit. It bears practically the same relation to the State government that counties do in most other States. The initiation of local public projects or activities, the raising of funds by taxes and indicating how these funds shall be spent are determined by a vote of the people in town meeting. Officials usually termed selectmen are elected to administer the affairs, expenditures are closely watched, and any project undertaken is usually carefully scrutinized. It is in this atmosphere that these publicly owned forests called town forests in New England have come into being in large numbers, where the idea is being actively nourished, and where they are already of local importance in one or more aspects.

Among the early, if not the earliest, States to authorize specifically the acquisition of municipal forests were Massachusetts in 1882, New Jersey in 1906, Pennsylvania in 1909, Minnesota, New Hampshire, and Indiana in 1913, and Vermont in 1915. Prior to specific legislation, however, there are records of town-owned forest land which met the specific purposes for which town forests are created.

One of these is the town of Danville in New Hampshire. To quote from the 1927–28 report of the New Hampshire Forestry Commission:

> This town has one of the most unique town forest records of any in the State. For 158 consecutive years or since 1790 this town has appointed a parsonage committee which have had as part of their duty the management of 75 acres of forest land—one a 55-acre piece and the other a 20-acre piece. This committee cut and used the lumber for the building and maintenance of the first meeting house and parsonage. During these years the receipts from the sale of wood have been deposited in banks until the fund has now reached almost $10,000. Every year at the March town meeting there is a warrant usually as follows: "To see how much of the parsonage fund the town will vote to spend for preaching for the year ensuing." Thus the town of Danville hires its own preacher and decides how much money they will pay him. * * *
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> The two tracts were probably set aside at the time the town received its charter and as was the custom in many towns were called the minister's lot. A careful study of the old parsonage committee records shows receipts from the sale of wood and timber up to about 1830. Many hundred dollars worth of timber is recorded as sold and used for repair of the meeting house, the parsonage and the fences about the two cemeteries. From 1830 until about 1880 the receipts came from rentals of pasture, the sale of rye and hay, making over $1,000 from this use. In 1865 another growth of timber had matured and $1,500 worth was sold at that time. In 1895 the records show that $4,500 was received at auction for sale of timber on the 55-acre piece and the money deposited in the bank. In 1903, about $1,200 was received from the sale of wood and timber on the 20-acre piece. With almost $10,000 in the bank as a result of this careful management, can any one doubt the wisdom of these parsonage committees in holding on to their two tracts of forest land?

In 1897 the town of Woodstock, in New Hampshire, acquired 25 acres of well-timbered land surrounding its water supply, and has cut much timber for highway and bridge construction from it. The town of Newington, N.H., lists as a town forest a tract of 122 acres acquired as long ago as 1710. The city of Fitchburg, Mass., claims the distinction of having been the first in the United States to establish a town forest under a State law. This forest was created on December 29, 1914, with an area of 109 acres.

The town forest movement has received its greatest impetus in the last 10 years. During the period from 1922 to 1930, the Massachusetts Forestry Association was very active in the State in urging town boards of selectmen year after year to consider the desirability and possibility of a town forest, offering to plant 5,000 trees free of charge for any city or town which would legally establish a town forest of 100 acres or more. The New England Box Co. for several successive years duplicated this offer to the towns of Franklin County. Similar offers were made for more limited periods by the Middlesex Forestry Committee to towns in Middlesex County, and by the Springfield Chamber of Commerce and the Hampden County Improvement League jointly to towns in Hampden County. The Berkshire Forestry Association offered $150 to each town in Berkshire County that would set up such a town forest. The result of these efforts in Massachusetts was to increase the movement of municipalities that had definitely entered land under the Town Forest Act from 4, at the beginning of 1923, to 90 aggregating 25,535 acres at the end of 1930. Some of these lands were already in town ownership. Some were acquired by purchase, by gift, and through tax reversion. In fulfilling its part of the contract, the Massachusetts Forestry Association planted 225,000 trees for 45 towns.

The State forestry departments of New Hampshire and Vermont have also urged such forests upon the town authorities. There was interest in this project in the highest circles. As late as 1930, previous to the town meetings held in March, Gov. John E. Weeks of Vermont sent a letter to all town selectmen in respect to owning and developing town forests. Following this particular letter 12 towns in Vermont appointed committees to consider the matter and several others appropriated funds to buy lands or to plant trees on land already owned.

On December 7, 1928, a meeting was held in Boston and an organization perfected of the Massachusetts town-forest committees, the only one of its kind in the United States so far as is known. It meets yearly to discuss town-forest problems and to make a field examination of one or more town forests. It appears destined to keep the subject of town forests in Massachusetts very much alive. The Massachusetts State Forestry Department is cooperating closely and has offered to map and make 5-year plans for any of the town forests upon request from the town authorities.

In New York the town-forest movement has made even better headway, in respect to number and total area of such forests. Fully three fourths of the total number in that State consist of lands surrounding the municipal water supplies. Some outstanding examples are the areas owned and developed by New York City and by Glens Falls. The movement in New York doubtless was given its principal impetus by the State law providing that the conservation department should furnish trees free of charge for reforesting such publicly owned lands. The number, area, and distribution of town and municipal forests, so far as these are known, are indicated in table 1.

TABLE 1.—*Town and municipal forests in the United States* [1]

Region and State	Forests	Area
New England:	*Number*	*Acres*
Connecticut	23	29,910
Maine	8	1,284
Massachusetts	90	25,535
New Hampshire	82	16,783
Vermont	42	9,000
Total	245	82,512
Middle Atlantic:		
Maryland	9	24,514
New Jersey	-------	56,397
New York	390	170,500
Pennsylvania	33	30,728
Total	432	282,139
Southern:		
Alabama	1	600
Georgia	5	1,103
North Carolina	37	43,911
South Carolina	1	10,436
Total	44	56,050
Central:		
Indiana	6	6,150
Missouri	1	2,000
Ohio	23	22,000
Total	30	30,150
Lake:		
Michigan	45	1,660
Minnesota	1	3,000
Total	46	4,660
South Rocky Mountain:		
Arizona	3	14,254
Utah	1	4,000
Total	4	18,254
Grand total	801	473,765

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[1] Not including a number of forests owned by cities in the Northwestern States to protect water supplies, about which data are lacking.

Thirty percent of the number of these forests and 17 percent of the area are found in the New England States, and 54 percent of the number and 60 percent of the area in the Middle Atlantic States. New York State alone accounts for 49 percent of the number and 36 percent of the area. This concentration is due to the firm belief in these regions in the benefits of a forest cover on the watersheds that furnish municipal water supplies, to a widespread and favorable public interest in public forests, and, in Massachusetts, to the active campaign put on by the Massachusetts Forestry Association.

Probably 50 percent of these forests, embracing 80 percent of the area, were acquired and developed primarily for the purpose of protecting the sources of municipal water supplies. There is intensive interest by their managers in protecting them from fire and even from insects, and in planting forest trees. About 68,000 acres of the total area have been planted. The communities in the New England and Middle Atlantic States are primarily dependent for their potable water supplies upon surface water that is collected in lakes and ponds. Its quantity and quality are a matter of vital concern to them. Efforts are not spared to keep this water pure and clean and to maintain a forest cover on the watershed.

In no case, so far as is known, have town or municipal forests in the United States been developed to the extent of those in Europe. They are usually made up of lands that needed planting when first acquired or of cut-over mixed second-growth timber that only years of careful expert management can bring to a highly productive state. The average size for the country as a whole is less than 600 acres; individually many are less than 200 acres and some less than 100 acres. The areas are too small to justify the employment of a technical forester to manage them. Occasional advice from consulting foresters is possible but so far as known has rarely been obtained. While State supervision or advice from the State technical staff might take care of that, it is true that at present town forests are legally subject to State supervision and direction in only two instances. The local man or men in charge of them may be perfectly capable of planting and protecting the lands but cannot be expected, without at least occasional technical advice, to go much beyond that stage in developing them. Because of their small size, their present condition, and the improbability of technical management, these forests are not now and do not yet promise to become very material sources of revenue to the political units that own them. Only the larger ones have potential possibilities in that respect. All of them will supply some timber and fuelwood—free fuelwood perhaps to the needy. Unless there are drastic changes in conception and administration, both of which are well within the realm of possibility, they are not destined to be of any material importance for timber production in the immediate future at least.

Town forests do create and hold local interest in the forest and in measures taken to protect them. That alone is worth a great deal. Most of them will continue to be given as good care as the men in charge are able to give. They will increase in number. Those belonging to growing municipalities which are obliged to extend their ownership of watershed lands, will increase in area. They could be and in some instances probably will become forestry demonstration centers of local interest and importance. Their chief value, and it is a very important one, will lie in the protection that they afford municipal water supplies. That will give them a more important status than if their purpose were the production of wood alone.

Following in the wake of the State park, which is rapidly assuming an important role in State developments, the town forest will in congested sections almost certainly play the role of a town forest park, a recreation center where facilities will be provided for rest and amusement. It may also serve as a game and bird refuge, or for some similar purposes. The extent to which town forests may be developed for such purposes is beyond anyone's knowledge. Without doubt the need for and appreciation of such areas will be realized more keenly year by year, and it is entirely likely that relatively small areas will be set aside in increasing numbers by local communities with a view mainly to their recreation value, rather than timber growing. There is no doubt that they will be heavily patronized, and will render in this way one of the well-recognized services of the forest, and will be well worth their cost.

Any estimate of the cost of these lands and the current expenditures on them could only be the roughest sort of a guess. Some of the land was acquired by gift, some by purchase, some through tax-delinquency, some through converting the old, so-called town farms into town forests and so on. Perhaps it averaged $4 to $5 an acre, which would make the total original cost to the towns about $2,000,000. The towns have been active in establishing forest plantations, which statistics show to aggregate about 68,000 acres. Since the towns ordinarily receive these trees free of charge from State nurseries, their actual expenditures for planting were probably about $350,000. There is no method of estimating what is spent yearly on these forests. Some towns have given them very good care, especially if one of their functions was to protect the water supply. Funds have been spent not only for general oversight, but for taking care of insect infestations such as the white pine weevil.

COUNTY FORESTS

The number and extent of county forests, as estimated from available records are summarized in table 2.

TABLE 2.—*County forests of the United States*

State	Forests	Area
	Number	*Acres*
Illinois	7	36,000
Michigan	1	320
New Hampshire		500
New Jersey	5	10,203
New York	34	18,384
Pennsylvania	1	40
Wisconsin	11	460,521
Total	59	525,968

It can hardly be said, in view of their small number and relatively small acreage, except in Wisconsin, that these forests are of great significance at present. Only in the four States of Illinois, New Jersey, New York, and Wisconsin, does there appear to be any real movement looking to the ownership and development of such areas. In the other States the small areas mentioned usually represent some tract or tracts of land that are a part of the land owned by one or more of the county institutions. The Illinois area of 36,000 acres is mostly in Cook County and is in reality a forest park for the city of Chicago.

In New Jersey, county forests have been established largely for the same purpose, that is, they are recreational areas set apart for people living in the congested industrial centers.

In New York and Wisconsin, real impetus has been given to the county-forest movement by special legislation which provides for State participation in the expense. In New York State the legislation provides for State contributions up to $5,000 a year to any county for the purchase of lands, for their reforestation, and for the protection of plantations or other forest growth thereon. While title to the lands is vested in the county, the State law provides that the area must be forever devoted to the purposes of watershed protection, of timber production, and other forest products, and for recreation and kindred purposes. This law is a close concomitant of another New York State law which provides for the purchase of lands for State forests. All lands owned or acquired by the county for the purposes mentioned are exempt from State and county taxes and for the purposes of all other taxes can be assessed at not to exceed the price paid for them, or, if acquired by gift, at the value thereof for forestation purposes but not exceeding the valuation as fixed upon the assessment roll 2 years prior to the gift. The board of supervisors of each county may sell trees, timber, or other forest products from these areas upon terms deemed for the best interests of the county and under such rules and regulations as may be prescribed by the conservation commissioner.

The three outstanding features of this law are (1) State participation in the purchase of land whose title is vested in the county; (2) the provision that the land must be forever devoted to the purposes for which it was acquired; and (3) the provision that sales of timber from the areas are subject to rules and regulations prescribed by the conservation commissioner.

In Wisconsin, tax-delinquent lands revert to the counties. From these lands, some 460,000 acres of county forests have been blocked out into forest units.

Wisconsin has definitely stimulated the creation of county forests. The forest-crop law of 1927 was amended in 1929 to permit the counties to list county-owned land as "forest-crop land." For every acre of land listed the State pays 10 cents annually to the township in which the land lies. The county pays nothing. As a further encouragement, the 1931 legislature ordered the conservation department to pay the counties an additional 10 cents to be used in the development of the forest units. Thus, every acre of county forest draws 20 cents of State money each year, 10 cents to the county and 10 cents to the township. The State in return is to receive 75 percent of the yield from the forests. County forests have been established in eight counties; other counties are hastening to get in on the arrangement.

In order to understand the alacrity with which the forested counties of Wisconsin are creating forest units, as well as properly to appraise the possibilities of future development, it is necessary to look into the financial conditions of these counties. In Wisconsin, real-estate taxes are collected by the townships which pass the county share on to the county treasurers. Some of the county funds are then returned to the townships as county aid for schools, etc. A special law permits the townships to turn over the delinquent tax lists to the county in lieu of cash. Thus, from many heavily delinquent townships the county receives little or no cash or may even be in debt to the township. In one county in 1931 the county levy was $140,000. Of this, $41,500 was received in cash, the balance of $98,500 in the form of delinquent tax lists. The county returned $40,000 to the townships for school districts, which left a balance of only $1,500 in cash for county purposes. The banks have refused further loans; the county is in distress.

When the county takes deed to the delinquent lands, as it is able to do after three years, the townships are no longer able to enter taxes against the lands and pass the charge on to the county. Thus, it is distinctly to the counties' advantage to take deed to the lands as rapidly as possible. If the land is then entered under the forest-crop law, both the county and the townships are further rewarded by the grant of State money. During the past year, counties have been taking deed to tax-delinquent land as rapidly as possible and are entering large blocks under the forest-crop law.

The purpose of the county forest law is good. The conservation commission is authorized to examine the areas offered for listing and determine that they are suitable for forestry purposes. It is empowered to supervise the expenditures of 10 cents per acre granted to the county for forestry purposes. The State is to receive three fourths of the yield from the forests. The disquieting phase of the arrangement is that most of the counties concerned are not financially able to enter into a forestry undertaking in any sort of an adequate way. They are not prepared to spend the funds necessary to make the land productive. There is little question but that the counties are taking up the plan primarily as a means of getting State aid.

The creation of county forests is a step in advance in that it involves a certain amount of rough zoning. It blocks up land which is unsuited to private development into forestry units and prevents further settlement in them. It stimulates local interest in forestry and it is probable that some progress will be made in developing some of the areas.

To men familiar with the forestry counties' financial situation in Wisconsin, however, and to those who have had contact with forestry undertakings of such local nature in other States, the county-forest plan seems to be but a transition toward State forests. It is possible that the units may remain nominally county forests for a long period of time, but the cost and responsibility for development must be largely assumed by the State.

The counties may become a more important factor in the Minnesota situation. Title to tax-delinquent land passes to the State in Minnesota after 5 years. In 1933, 4,000,000 acres will be involved. The State is to hold the land as trustee for the various taxing units in the proportion of the unpaid taxes. The State's equity in these taxes is usually less than 10 percent. There is a considerable disposition among the local county and township officials to feel that under these circumstances the county should have the determining voice in regard to what is done with the land rather than the State. It remains to be seen what kind of division of responsibilites will be worked out in Minnestoa.

As matters now stand there does not seem to be a well-defined national movement for the acquisition, retention, and development of county forests as productive pieces of forest property under county administration. The New York situation seems most clearly defined because of the rather generous financial participation by the State provided for by the law. The Wisconsin situation is clearly a social and economic movement designed to assist counties whose idle and delinquent tax land is simply overwhelming them. To assure success of the movement, additional funds and effort must be put into it.

Ownership and development of forest units by counties would have some advantages over ownership by the smaller town unit. Funds for the purpose could presumably be raised in greater amounts and larger areas could be acquired and maintained. Areas large enough to justify the employment of a technically trained forester might conceivably be set up in a great many counties. The possibility of developing public forests through setting aside tax-reverted land for that purpose is more pronounced in the case of counties than for any other political unit. In about half of our States, tax-delinquent lands revert to the county rather than to the State or town. Where State laws permit it, such lands of suitable character could be set aside as county forests. To be most effective, legislation should provide not only for designating some of such land as county forests, but make it easy and inexpensive for the county to take title to the land, and should provide for exchange of one parcel of land for another. This would facilitate blocking up a comparatively solid area of land as the county forest. Precise information is lacking as to the amount of land that has reverted to the counties for taxes but apparently it amounts to several millions of acres. Developing part of it for county forest purposes would be one means of putting it to a use that would make it a social and economic asset. It would serve largely the same purposes as the town forest already discussed, timber production in time, and meanwhile watershed protection and an area for public hunting and fishing and other forms of recreation. To be sure, all counties could not do this. Some could not finance such a project, even though compared to some other county activities, its cost would be insignificant. It would be necessary for the States to provide financial aid. To assure continuity of and ability in management, supervision by the State forester should be provided in these cases.

CURRENT FOREST DEVASTATION AND DETERIORATION

By R. M. Evans, Assistant Regional Forester, Eastern Region

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INTRODUCTION AND DEFINITIONS

> The depletion of timber in the United States has not resulted primarily from the use of our forests, but from their devastation. The kernel of the problem lies in the enormous areas of forest land which are not producing the timber crops that they should.

This statement from A Summary of the Report on Timber Depletion and Related Subjects Prepared in Response to Senate Resolution 311, in 1920, is typical of many which have been made during the 12 years since it was written. It expresses the widespread belief that cutting, which removes the timber from at least 10 million acres, and fires, which burn over more than 41½ million acres each year, are depleting the forest growing stock and rapidly reducing much of the country's forest lands to unproductive wastes. Upon this belief the demand for public regulation of private forest land is largely based.

Before intelligent consideration can be given these problems, the two terms, forest devastation and forest deterioration, need to be defined. The difference between the two conditions is one of degree rather than of kind. For the purposes of this statement—

Devastated forest land is land that without artificial restocking will not produce a commercially valuable crop of timber within a tree generation.

A *deteriorated* forest or stand is one which, because of the treatment to which it has been subjected, has had its capacity to produce desirable wood or other forest products greatly reduced when measured in terms of value, either of quality or quantity.

Deterioration, unless stopped, progresses ultimately to devastation. Land classified as devastated is not necessarily bare of all vegetative cover, the criterion being the production of a commercially valuable crop of timber within a tree generation. They are elements of the same problem, but they can best be examined separately.

CURRENT FOREST DEVASTATION

The present total area of commercial forest land in the United States is considered to be about 495 million acres. Of this, about 20 percent is old growth; about 67 percent is second growth, cordwood areas, and areas with some degree of restocking; the remainder, about 13 percent, or more than 60 million acres, will not produce a commercially valuable timber crop within a tree generation without artificial reforestation. The extent to which planting is justified is discussed in the section entitled "The Reforestation of Barren and Unproductive Lands" of the chapter on national programs required and the responsibility for them.

This vast area of unproductive land is increasing at the rate of about 850 thousand acres annually; but at the same time a certain area of land long ago devasted is gradually becoming forested, partly, at least, compensating for the current devastation. However, there is such a lapse of time in the reforestation of the long devastated areas that millions of acres lie unproductive for decades.

The chief causes of devastation, now as in the past, are cutting and fire. Either one can cause devastation, but the bulk of the damage is the result of fire after cutting. The conditions set up by logging invite fires and increase their damage. About three quarters of the area devastated currently is in pine and other softwood stands, in which cutting produces large accumulations of highly inflammable slash and debris. A single fire in such slash may, and frequently does, destroy all young growth and trees of seed-bearing size, leaving the area incapable of restocking by natural means. The partial devastation of a less severe fire is likely to be completed by later burns. Among other causes of devastation is overgrazing, especially in the farm woodlands of the Corn Belt. Insects and disease may complete the destruction of trees weakened by fire, as often happens in second-growth stands of the southern pines. All causes sometimes combine on a single area. Table 1 shows the area of forest land being devastated annually in the several broad forest regions.

TABLE 1.—*Estimated area of forest land devastated annually*

	Acres
New England	11, 000
Middle Atlantic	6, 000
Lake	90, 000
Central	140, 000
South	415, 000
Pacific coast	115, 000
North Rocky Mountain	76, 000
South Rocky Mountain	0
Total	853, 000

ON HARDWOOD AREAS

The great hardwood producing region lies east of the Great Plains. It includes the beech and maple stands of New England, New York, Pennsylvania, and the northern Lake States, the oak-chestnut-yellow poplar stands of the southern Allegheny and Appalachian Mountains, the oak-pine stands of the piedmont, the river-bottom hardwoods of the lower Mississippi Valley, and other southern alluvial valleys, and the oak-hickory stands of the Central States and southern Lake States. For many years this vast area has been cut severely and burned frequently. These processes still continue, but the hardwood forest, through its ability to perpetuate itself by sprouting, exhibits a remarkable resistance to complete devastation. Deterioration, on the other hand, is widespread and serious.

In the Middle Atlantic region, mine-prop operations, fuel wood and chemical wood cuttings in second-growth stands or following logging, take trees down to 2 to 3 inches in diameter, often stripping an area clean. Fires in the heavy accumulations of slash which result from such severe cutting have frequently destroyed the sprouting capacity of stumps and resulted in devastation. Upwards of 50 thousand acres of land in this condition are included in the areas purchased for inclusion in the Allegheny National Forest in northwestern Pennsylvania. In the same State, upwards of 2 million acres have been so wrecked that they now support only a cover of bracken, huckleberries, and weeds or scrub oak, fire cherry, and aspen. Similar areas are found in neighboring States. The processes leading to devastation are still going on in these States, but less rapidly.

In the central region, fires in heavy slash following logging devastate considerable areas in the manner just described. In areas of heavy concentration of livestock, such as the Corn Belt, the custom of pasturing the farm woods is the biggest obstacle to the natural regeneration of timber.

When the livestock are numerous and are concentrated in woods of relatively small area, as in most of the farm woodlands, the result is always the same. The young growth is eaten, broken, stripped of bark, bent, or trampled out and new growth does not take its place. Grasses work into the woods from the edges and in the small openings. The older trees gradually die in the tops and are then usually cut out by the owner. The result is a gradual transition from a rather dense woods to a wooded pasture in which the trees continue to die off and decrease in number from year to year. This means the gradual elimination of the farm woods.

Over 70 percent of all farm woods in the Corn Belt is used for pasture. According to census reports from 1910 to 1930, the area of farm woods in this section is decreasing about 2 percent annually.

ON EASTERN SOFTWOOD AREAS

Devastation in softwood forests is more widespread and serious than in hardwoods, since softwoods are, in general, less able to resist fire and destructive logging.

In New England, devastated areas to the extent of nearly half a million acres have accumulated during the past 30 years or more.

In the spruce-northern hardwood region, existing devastated areas are confined largely to steep and rocky slopes which have been severely burned following logging. A severe fire in this region may leave the rocky surface almost bare of soil. This exposure of rocky slopes is accentuated by erosion following the fires. It is a matter of written record that some of the mountain tops now entirely bare rock were, within the memory of man, covered with dense growth of spruce forests; destruction of the forest soil by fire has resulted in making new growth impossible. However, with the passing of large-scale logging operations and the inauguration of systematic fire protection, the area of such land now subject to devastation is much reduced.

In the pine region of New England, devastated areas include the sandy plains which have been subjected to repeated fires following removal of the original timber. These areas have been reduced to worthless growth of scrub oak and pitch pine. The fire hazard on these plains is extreme, and past efforts at reforestation, as well as natural reproduction, have been largely wiped out by subsequent fires. Most of the present annual increase in devastation is in the pine types.

In the Lake States, forest devastation began with the rise of commercial logging about 1850 and reached its peak about 1910. As the area of cut-over land increased, slash accumulated and fires became more and more common, in bad years reaching catastrophic proportions. With the decline of destructive logging and its vast accumulation of slashings, standing snags, and other inflammable material, the conditions essential for severe conflagrations resulting in extensive forest devastation have also declined. Of the 560,000 acres burned annually, some 90,000 acres are left in a devastated condition.

In the South, no devastation of consequence, within the meaning of the definition, is going on in hardwood types, although deterioration is serious. Of the possibly 415,000 acres estimated as being devastated annually in the pine types, nearly 90 percent is longleaf and slash-pine land. The major causes of this devastation are cutting, fire, turpentining, and hogs. Turpentining, however, seldom causes devastation unless followed by cutting and fire, but may be a potent cause of deterioration.

Good stands of longleaf in the western Gulf States, frequently running from 10,000 to 15,000 board feet to the acre over large areas, have invited the use of skidders, which, as ordinarily operated, break down or cripple many of the trees left standing by the fallers. An example of practically complete denudation is a tract of longleaf pine land in southwest Louisiana cut over between 1914 and 1919. It originally bore a stand of about 15,000 board feet to the acre of prime timber. A tally was made in 1925 of the standing trees and seedlings on a strip two chains wide run at random for 4 miles through the tract. This showed, on each 5 acres, less than one living pine 4 inches diameter breast high or larger, and generally this occasional tree was so small or crippled as to be incapable of seed production. Longleaf seedlings averaged only 28 to the acre. In this example, fire played a part, as it does elsewhere. Similar logging methods are still employed on other tracts in the South, although less extensively now, because of the rapid disappearance of the heavy old growth stands. In some localities, trees left in logging are cut for piling, poles, and posts, and devastation is made complete by the removal of even the stumps for distillation.

Longleaf pine seedlings have remarkable fire resistance except during the first two or three months following germination and again during the 2 or 3 years following the beginning of height growth. During these periods, fires at any season of the year may destroy a considerable proportion of the young trees. Fires occurring during the growing season are the most destructive.

Hogs are serious enemies of longleaf pine seedlings. These animals, either of the razorback or more domesticated variety, can wipe out in a few months a stand of young longleaf pines as much as 5 or 10 years old. Damage is particularly serious around settlements.

The wet areas in which slash pine commonly occurs do not burn often, but when dry enough to burn make very hot fires because of the abundant vegetation. When such fires occur, especially in young stands, devastation is very likely to result.

Pure stands of virgin shortleaf pine on poorer sites are occasionally denuded by close cutting and fire. In general, however, this pine, producing seed more abundantly and at shorter intervals than longleaf and growing in lighter stands which are less well adapted to the profitable use of steam skidders, suffers little devastation.

ON WESTERN SOFTWOOD AREAS

In the great softwood-producing regions west of the Great Plains in the Rocky Mountains and on the Pacific coast, it is estimated that forest lands are being devastated at the rate of 191,000 acres annually. The bulk of this acreage, more than 95 percent in fact, is in Idaho and Montana, and in the Douglas fir forests west of the Cascades in Oregon and Washington. Here as elsewhere in the country this condition is brought about by fire and logging as the prime causes. While the logging operation itself is seldom so destructive or complete as to cause forest devastation, and tree stands of seed-bearing age are seldom so destroyed by fire that a loggable crop cannot be produced within a tree generation, fires in slash following logging, and in stands of seedling and sapling age are particularly damaging. These fires, and fires that burn the same area the second or third time, are responsible for most of the current devastation of forest lands.

The cumulative effects of logging and fire in the Douglas fir region are illustrated by the results of a study of areas cut over from 1920 to 1923. To determine the condition of the reproduction on these areas, 105 miles of transects were run in seven counties. Analysis of the data indicates that about 40 percent of the area is nonstocked, 30 percent poorly stocked, 15 percent medium stocked, and 15 percent well stocked. It may be assumed that land being logged now and subjected to the same combination of influences for an equal period will be reduced to a similar condition.

Much of the private land logged over for white pine in Idaho and Montana has been burned after cutting. Unmerchantable species and defective trees or trees below merchantable size left uncut are prey to the first slash fire, which kills much of this material. In a few years these dead trees begin to fall and often create a fire hazard comparable with the original slash. As a result, much cut-over white pine land has burned a second time. The tangle of dead and down trees, the snags still standing, the undergrowth of thistle, dry grass, and fireweed altogether form so combustible a combination that it is difficult, within reasonable limits of cost, to protect it from fire or to stop a fire that has started in it. Probably 25 percent of the cut-over land in the white-pine type in north Idaho is in nonproductive condition because of fire.

In the past few years, more strict enforcement of State fire and slash disposal laws in Idaho and Montana, together with a growing desire on the part of private operators to comply with these laws, have greatly reduced the forest acreage devastated as a result of slash fires.

The ponderosa pine types east of the Cascades in Oregon and Washington and the related types in California are less subject to complete devastation by fire than the Douglas fir forests and the white pine forests of Idaho and Montana. This is due to the uneven age of these stands and their open character which permit the logging of the larger merchantable trees without harm to the seedlings, saplings, and immature trees that are usually present. However, these types are not immune to destruction. Fires in slash following logging can and do destroy all tree growth.

An outstanding example of the effect of man on the forest is found in Eldorado County, Calif., where the ponderosa pine belt is being pushed back and up the Sierra slopes. Because of man and his occupation of the land, there has been a retreat of nearly 10 miles from the 1,000-foot to the 2,500-foot level on a 30-mile front, leaving a deforested area of about 160,000 acres. In addition, there is an area of second growth nearly as large, three fourths of which is less than half stocked. And this condition is typical not only of the entire western front of the pine belt in the Sierra Nevada but of the Douglas fir belt of the California coast ranges. The change from forest to deforested land has come about very gradually. Some of the deforestation may be attributed to the Indian, but undoubtedly the larger part has occurred since the advent of the white man, whose first inroad probably began with the establishment by Capt. John Sutter of a sawmill at Coloma. By 1870 the lower ponderosa pine belt had been largely logged off. Successive fires have completed the change.

In the redwood type, high-speed power logging and severe fires, as a part of the logging operation for slash disposal and subsequent fires resulting largely from carelessness, leave cut-over areas in bad condition, but the sprouting capacity of redwood is insurance against complete devastation in all but the exceptional cases.

Insects are a contributing factor in rendering softwood lands nonproductive. When extensive outbreaks of insects develop in forest types composed chiefly of one species of tree or several species that are subject to attack by the same insect, a high percentage of the stand may be destroyed. The standing dead trees go down in the course of a few years, making an impenetrable tangle of tree trunks and tops through which reproduction is struggling. Fire starting at this stage is difficult to control. Outbreaks of the mountain pine beetle in lodgepole pine have been followed by fires which left great areas destitute of timber for many years. Outbreaks of defoliating insects in the spruce-fir type of the Rocky Mountains frequently destroy every tree, even down to an understory of reproduction. Fire that starts under these conditions likewise leaves barren land in its wake. Many bald ridge tops and barren scars in the mountains of Arizona and New Mexico are unquestionably the result of outbreaks of defoliating insects followed by fires.

Available data indicate that new areas are being devastated at the rate of about 850,000 acres each year; but against this annual increase should be credited an allowance for the new forests that are growing up slowing on areas long ago devastated. It may, indeed, be doubted whether there is any net annual increase in the total area of devastated forest land. Protection from fire, abundant seed crops, and moisture conditions favorable for the establishment of seedlings following the period of germination are among the influences tending to reestablish tree growth on areas long unproductive. In the Lake States, for example, with better protection from fire in effect in recent years, much of the cut-over forest land is being restocked naturally with tree growth of some kind, usually jack pine, maple, and aspen. In the South and in other regions, there is a similar tendency for long-denuded forest land to become restocked, often, however, with a stand inferior in quality or quantity. A period of several decades may elapse before the favorable influences become effective, and during that period devastated lands are adding nothing to the forest capital of the country. Until the devastation of new areas is stopped, material reduction in the total unproductive forest area of the country is not to be expected.

CURRENT FOREST DETERIORATION

An adequate growing stock is essential to a continuous cut of wood products sufficient to supply the needs of the country. The deficiency in existing growing stock (discussed in the section entitled, "Present and Potential Timber Resources") is due chiefly to the deteriorated condition of cut-over and second-growth areas brought about by fire and cutting methods based for the most part on the realization of present values without regard for the perpetuation of a productive forest. In the aggregate, considerable areas are in satisfactory growing condition and are producing a reasonable amount of wood fiber, but this condition exists more by chance than by design.

Fire and cutting are the most important and universal causes of forest deterioration; they also are subject in a large measure to human control. Frequently they operate together and the effects of each are difficult to separate. Insects and disease also destroy vast quantities of tree growth, thus lowering the productive capacity of the forest, but they are more or less inevitable in nature. The degree to which they may be controlled is discussed elsewhere in this report. Their net effect is to contribute to and to extend the deterioration resulting from cutting and fire.

EFFECTS OF FIRE

IN HARDWOOD STANDS

In many of the hardwood stands of the East it is the custom to burn the woods annually to keep down the brush and undergrowth, to improve grazing, to make hunting easier, and for numerous other reasons. Such fires have been so widespread and of such common occurrence for so many years that their importance from the standpoint of maintaining a productive forest is often overlooked or minimized. Because they do not devastate hardwood stands to the same extent that they do softwoods, the fact has been overlooked that fires are among the most deteriorating of all influences in the hardwood forest. On reproducing areas the proportion of hardwood sprouts is increased and the composition of the stand may be radically changed. In young stands, more small trees than large ones are killed or injured. Fire, therefore, affects the future of the forest more than it does its present condition. Stands are destructively thinned, leaving the land occupied by the older, often overmature trees and by young trees crippled by wounds and subsequent decay. The treatment of second-growth stands in which many of the trees have been injured is one of the most difficult problems of the forest landowner.

Fires are more often fatal to small than to large timber, but perhaps the greatest loss is in trees that are wounded but not killed. Trees injured at the base usually do not die but continue to grow and occupy space. Many of them become infected, through the fire scars, with wood-rotting fungi. The decay may sometimes be arrested, but it may also spread in the wood of the trunk, greatly reducing the quantity and value of the final product. The trees thus crippled continue to spread their crowns and thus prevent the successful development of reproduction. In a study by the Forest Products Laboratory of small sawmill utilization in Appalachian hardwoods, it was found that three fifths of the total defect was attributed to fire injury. The total defect in this instance amounted to 25 percent of the volume.

The effect of repeated fires on a hardwood forest is well brought out by the results of a study made by the Central States Forest Experiment Station in a mixed oak stand in northern Arkansas, the results of which are summarized in table 2. Here will be seen that defective trees comprise from 22 to 65 percent of the total number by species and size class, and that the smaller size classes contain the most defective trees. This means that the young growth upon which dependence for the future stand must be placed, is already 50 percent or more defective. A fact worth recording is that only three trees on the 105 plots were surely of seedling origin.

TABLE 2.—*Composition of stand and percentage of defective trees following repeated fires in a mixed oak stand, Arkansas* [1]

Diameter breast high group (inches)	White oak		Black oak		Red oak		Other species	
	Trees per acre	Defective	Trees per acre	Defective	Trees per acre	Defective	Desirable	Undesirable
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
2.6 to 11	7.62	42.5	9.52	65.1	4.37	27.4	4.00	26.87
11.1 to 17	4.62	52.3	4.71	54.7	1.52	39.1	.57	4.91
17.1+	4.52	22.5	2.28	30.6	1.39	22.7	.15	.97

[1] Based on 105 plots of 0.2 acre.

In the same study, 435 sprouts, ranging in size up to 2.5 inches, were cut and the condition of the stem recorded. (Table 3.) One-third of the white and black oak reproduction (the most desirable components of this stand) show decay in the stems. Obviously the future of this stand is not promising.

TABLE 3.—*Defect in sprout reproduction*

Species	Sprouts cut	Sprouts showing rot	
	Number	*Number*	*Percent*
White oak	149	52	34.9
Black oak	127	41	32.3
Other oaks	20	7	35.0
Hickory	120	24	20.0
Chinquapin	2	0	0
Ash	4	0	0
Red maple	13	2	15.4
Total	435	126	
Average			29.0

The two illustrations given are more or less representative of what has happened over much of the eastern hardwood region.

In addition to the killing and wounding of trees, fires cause a heavy loss in soil fertility by destroying the leaf litter. The effect is to reduce the growth capacity of the soil. A marked change in growth conditions can often be noticed, as when a poor, slow-growing young stand develops, after fire, among better trees of a previous generation.

The effects of fire in hardwoods are quickly obscured by the ability of the young growth to sprout, but even a single fire sets the stand back several years on the road to merchantable size and a profitable return to the owner.

IN EASTERN SOFTWOOD STANDS

It has been estimated that at least 99 percent of the pine lands of the South are today producing less than a full crop of wood and naval stores. This deplorable condition has been brought about by uncontrolled fire, cutting, destructive turpentining, and, locally, by hog damage. Successful fire control alone would in time bring probably 90 percent of the southern pinelands to a higher degree of productivity than they have known in the white man's day. Uncontrolled fires have been, and still are, the greatest cause of failure of the southern pines to reproduce naturally and fully throughout their range, and they are still a main obstacle to timber growing in the South.

Much loss of second-growth slash and longleaf pines in the eastern part of the pine region, particularly in Georgia and Florida, follows the destructive turpentine methods commonly used. Many trees are chipped when too small and are given too many faces. Gutters are often driven unnecessarily deep into trees, chipping is often as deep as 1½ or 1¾ inches, and front and back faces are commonly run into each other. Fires ravage abandoned orchards, and trees which do not burn down are often so weakened as to be snapped off by high winds or to fall easy prey to insects. Composite figures for three representative stands, cupped for an average of 5 years, and abandoned, on an average, 1 year, show that 29 percent and 15 percent, respectively of the turpentined slash pine and longleaf pine trees, 6 inches to 16 inches diameter breast high are dead.

All destructive agencies have combined to convert large areas of longleaf land to stands of scrub oak and palmetto. Probably 3 million acres of this kind of land are in Florida alone. This worthless cover is worse than none since it forms an effective bar to regeneration either by planting or by natural seeding from the occasional tree of seed-bearing size that still persists.

In the Lake States where commercial logging was at its height from 1850 to about 1910, some 5 million acres out of a total of nearly 56 million acres of forest land now support a stand of merchantable saw timber. Seven million acres are unstocked, and the remainder supports cordwood or unmerchantable second growth. Owing to understocking and poor silvicultural condition, timber production on the area as a whole today is estimated to be but a third of what it should be. In addition, inferior species have for the most part replaced the more valuable pines and hardwoods which made up the original stand. Vast areas have been converted to jack pine and aspen. Much of the aspen, due to small size and defect, has no commercial value, but hinders regeneration of other species, either natural or artificial. Often it is worse than no cover at all. The magnitude of the problem is indicated by the fact that aspen occupies some 21 million acres in this region.

IN WESTERN SOFTWOOD STANDS

In the California pine region repeated fires have resulted in thousands of acres of waste land or unproductive brush fields, of areas on which the type is changing to less valuable species, and of cut-over lands that fail to reproduce. Each fire accelerates the progress and effects of the next. Where logging has been in progress, the broadcast slash fire has been permitted to sweep over with perhaps little apparent damage; but in its path reproduction, the basis of the new forest, is gone and will return only after many decades. Under such conditions, the few seed trees left are weakened and are often prey to the first strong wind. Brush gradually takes over the area.

As an example of what happens on private land, the cumulative results on one large operation over a period of 20 years show that on 16.7 percent of the total area the stocking was 60 percent or better; on 52.4 percent of the area the stocking was 10 to 20 percent complete; and on 30.9 percent the stocking was 0 percent. The deficiency is largely due to slash fires. The result of neglect of cut-over lands is quite as likely to be a forest partly stocked, patchy, and damaged by fire and disease as it is to be complete denudation. Hundreds of thousands of acres of cut-over lands are similarly producing wood at only a fraction of their potential rate.

During recent years there has been a tendency for private cut-over lands to be left in better condition. The quite general substitition of tractors for the destructive large donkey has resulted in leaving more trees of small sizes, and fire protection has been more effective.

In the redwood region, high-speed power logging and severe fires (including both escaping slash fires and those resulting from carelessness) are the causes of severe deterioration and even devastation. Whipping of lines and the deliberate pulling over of "leave" trees effectively remove any trees that might form the basis for a seed supply. The ability of redwood to sprout from the stump when cut at any season of the year results in stands 25 to 35 per cent stocked with this species, except when the areas are repeatedly burned; but the Douglas fir that is the principal associate of redwood is practically eliminated from the stand by slash fires which kill the trees surviving the logging operation. A system of logging and slash disposal which saves seed trees would make all the difference between such a sparse stand of redwood alone and a mixed stand 80 percent or more complete.

In the heavy, dense stands of the Douglas fir region in Oregon and Washington, logging methods and the use of fire to dispose of slash do not differ materially from those described for redwood stands. Studies have indicated that the customary repeated fires over a period of years will result in poor stocking on about 30 percent of the area cut over annually, or about 65,000 acres.

It is clear that forest land dedicated to timber production must be assured protection against fires throughout its timber rotation. Fires damage forest values and in many regions ultimately convert valuable types into low-grade, poorly stocked forests. Even the lightest surface fires, if repeated frequently enough, seriously reduce the growth capacity of the forest. In many regions, tree-killing insects and wood-destroying fungus diseases invariably increase as a result of fires. Regardless of the extent of damage, fires have the effect of depreciating the forest. The extent to which this process has been going on in the United States is indicated in table 4.

TABLE 4.—*Average area of forest lands burned annually in the United States, 1926–30*

Region	Area burned over	Region	Area burned over
	Acres		*Acres*
Pacific	1, 283, 598	South	37, 571, 504
North Rocky	283, 882	Middle Atlantic	338, 304
South Rocky	23, 111	New England	95, 884
Lake	563, 536		
Central	1, 379, 076	Total	41, 538, 895

About 41½ million acres annually burned over must be considered as a major contributing cause to the problem of deterioration and devastation, regardless of whether these fires cover cut-over lands, second-growth stands or virgin forests. While the damage as a result of fire may vary from region to region, the ultimate effect is reduced forest values on practically every acre burned over. The process of repeated burning, which is particularly common in the South, demands intensified protection effort against fires if the forests are to be built up to somewhere near their growth capacity.

EFFECTS OF CUTTING

IN EASTERN HARDWOOD STANDS

Destructive methods of cutting have resulted in decreased value of remaining stands by repeated cullings for the more valuable species, change in composition, and poor stocking of cut-over areas through failure to make provision for reproduction.

These conditions may be illustrated by the results of private cuttings in the Appalachian hardwood region. The forests of this region are exceedingly complex. About 140 species of trees are native, of which about 60 are important commercially. The kind and quality of products that could be profitably exploited have undergone a marked change during the comparatively short period since large scale operations began. Forty-five years ago only the walnut, cherry, and the finest of the yellow poplar, northern white pine, basswood, cucumber magnolia, and white oak were worth taking. Commonly only a light culling of the forest was made. Very few trees were logged that were under 30 inches on the stump, and no logs were taken at the mills that were less than 20 inches in diameter at the small end. Ten years later, the usual cutting limit was 24 inches on the stump, and logs 18 inches in diameter could be handled in the mills. By about 1900, the average cutting limit in the woods had dropped to 21 inches on the stump and the average small-end diameter of logs at the mill to 17 inches. By 1905, oak and chestnut trees 15 inches on the stump and poplar 14 inches or even less were being taken. More recently, in seasons of active movement of lumber, trees 9 to 10 inches on the stump have been cut for lumber by large mills, while portable mills have cut to even smaller diameters, in spite of the fact that trees of such small diameters can rarely, if ever, be handled except at a loss.

Meanwhile, markets developed for species and products which had no value in the early days of logging. The changes in market conditions resulted in constantly heavier cuttings of the forest and less timber left standing. Until comparatively recent years, however, enough was left to justify the reworking of areas already cut over. As a consequence, a large part of the timberlands has been cut over again and again, sometimes six or eight times. It is estimated that 90 per cent of the mountain timberland in the Southern Appalachians is more or less depleted of merchantable timber. The natural replacement with thrifty second growth is handicapped by defective and unmerchantable trees left standing after logging.

In studies made by the Applachian Forest Experiment Station to determine the existing conditions of remaining trees and reproduction on the usual type of repeatedly cut-over, but not clean cut, hardwood lands that have escaped recent fires, it was found that good trees of desirable species in five different forest types averaged as few as 14 percent and in no case more than 26 percent of the total number of trees 3.1 to 9 inches diameter breast high on the average acre examined and from 29 to 48 percent of trees over 9 inches diameter breast high on the same acres. The remainder of the trees consisted of poor specimens of desirable species and less desirable species, both good and poor.

The deficiency in stocking is emphasized further by the data in table 5 from the same study. The indicated deficiency in wood volume ranges from 41 to 58 percent. The wood volume alone, however, does not tell the whole story of the cut-over stand, for a part of it is made up of defective trees and of trees of the less desirable species.

TABLE 5.—*Estimated deficiency in stocking in stands on unburned cut-over lands when compared with well-stocked second-growth of corresponding site quality and similar average diameter breast high, by forest types*

Forest type	Average cut-over stand 3 inches or more diameter breast high			Well-stocked second-growth stand			Estimated volume deficiency in cut-over stands	
	Trees per acre	Average diameter breast high	Volume per acre	Trees per acre	Average diameter breast high	Volume per acre		
	Number	*Inches*	*Cords*	*Number*	*Inches*	*Cords*	*Cords*	*Percent*
Dry slope and ridge:								
Black oak-scarlet oak type	120	9.7	22	241	9.7	44	22	50
Chestnut oak type	159	7.6	16	326	7.4	31	15	48
Moist slope and cove:								
Cove hardwood type	149	9.2	26	318	8.8	53	27	51
Northern hardwood type	95	11.2	28	285	10.0	67	39	58
Chestnut type	192	8.0	24	352	7.8	41	17	41

The proportion of straight, sound trees of desirable species in the cut-over stand is shown in table 6, and brings out well the evidence of overcutting. In not one of the forest types represented are as many as one half of the trees straight and sound and of desirable species. Among the small trees, the inferiority is the more pronounced. Three quarters or more of the trees in this size class are of the less desirable species or defective; and these stands, not having been burned severely or recently, are presumably in better condition than the large areas of cut-over forest that have been fire swept.

TABLE 6.—*Proportion of good trees (i. e., straight, sound trees) of desirable species in typical unburned cut-over stands, by forest type*

Forest type	Trees 3.1–9 inches diameter breast high		Trees 9.1 or more inches diameter breast high		Total of good trees	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Dry slope and ridge:						
Black oak-scarlet oak type	20	26	16	37	36	30
Chestnut oak type	29	24	17	47	46	29
Moist slope and cove:						
Cove hardwood type	28	25	18	46	46	31
Northern hardwood type	10	17	17	49	27	28
Chestnut type	23	15	10	29	33	17

Reproduction of desirable species, inadequate at best, is hindered in its development by shade and competition. This condition is illustrated in table 7, which summarizes the results of an examination of a typical cut-over area on a better than average site in the mountains of North Carolina. Here the reproduction of desirable species is dominant on 24 percent of the area, but the development of a third of it is being retarded by overhead shade. Only 16 percent of the area is stocked with dominant reproduction of desirable species free to grow.

TABLE 7.—*Stocking of desirable, dominant reproduction, shaded and unshaded, on a typical cut-over area of better than average site, North Carolina*

Species	Shaded	Unshaded	Total
	Percent	*Percent*	*Percent*
Yellow poplar	3	7	10
Chestnut oak	1	3	4
Black locust	1	2	3
White ash, white oak, basswood, black cherry, cucumber	3	4	7
Total	8	16	24

The effects of repeated culling of the southern Appalachian forest at short intervals may be summed up briefly. The best species were logged earliest and most persistently; this reduced their seed supply and decreased their abundance in the reproduction as compared with the poorer species. Valuable species have been cut heavily to very small sizes. This has reduced the quality of the second growth by increasing the proportion of the poorer species. The effect of cutting always the best species, large and small, is that of a constant attrition, perhaps not marked at any one time, but cumulative and tending toward the elimination not only of the trees themselves but also of means for their natural reproduction in future stands. Moreover, not only the best species but the best trees of all merchantable species have been cut, increasing the proportion of the poorest. Defective trees left standing in the southern Appalachian forest occupy thousands of acres in the aggregate and interfere with the continuity and success of second growth.

Chestnut blight is among the factors contributing to deterioration of stands in the southern Appalachians. As a result of this disease, chestnut has practically disappeared from the forests of southern New England and the Middle Atlantic States. Although chestnut is still the most abundant timber tree in the southern Appalachian Mountains, the disease is now established throughout the commercial range of chestnut in the South.

Satisfactory replacement with other species is generally to be expected, but the loss of chestnut will nevertheless have a deteriorating effect in many ways. It will greatly change the composition of the forest, and will also substantially reduce its productivity, since chestnut grows faster than most of its associates. Successive, short-lived generations of sprouts from blight-killed chestnut, with their tendency to spread out and monopolize growing space, endanger the development of other hardwood reproduction. This danger is augmented in mixed stands by the growth of shrubs and the shade from living trees. The tendency of the crowns of undesirable "hold-overs" to expand and fill openings left by the death of the chestnut increases the shade still further. In the southern Appalachians this problem is rendered acute by the fact that some of the most desirable tree species are not able to endure prolonged shading.

The present actual growth rate on southern Appalachian forest land is obscured by lack of specific data. Examination of many tracts scattered through the region indicate that a large part of such growth as is taking place is distributed among trees of little or no commercial promise. Such trees fall chiefly into the classes of large unmerchantable rejects from past logging, and smaller trees rendered defective by fire, decay, insects, or other causes. Although many excellent small stands are scattered throughout the region, it is safe to say that southern Appalachian timberlands as a whole are not making one third of the growth which the soils are capable of maintaining.

Deterioration of southern Appalachian hardwood stands has been described in considerable detail since the processes which are at work here are the same as those which affect other hardwood regions of the eastern half of the United States.

In New England, deterioration of forest land has been widespread. It has resulted from clear cutting, or repeated culling, and fire. In the spruce region, deterioration has been especially marked as a result of culling first for pine, then for spruce lumber, and finally for spruce and fir pulp, without any attention to the hardwoods. The residual hardwoods are very defective and have spread out to occupy the space to the detriment of new growth which might be on the ground. A serious problem of future utilization has been created over thousands of acres in this way, and in addition, large areas which formerly bore mixed stands of softwood and hardwoods have now become almost entirely hardwood.

Hardwood stands in all sections which have been repeatedly clear cut on a short rotation for fuel wood or other products have shown a deterioration in composition—red maple, gray birch, aspen, fire cherry, and smaller weed species increasing at the expense of the more valuable commercial species.

Perhaps the most serious phase of forest deterioration in New England has been the steady reduction of growing stock and a consequent loss of many of the more important forest industries. In the past history of the region, exploitation has proceeded in stages, each stage utilizing trees and stands of smaller size then the preceding, and each making a return of the former type of utilization more and more difficult. The quality of the products has been steadily declining in this process.

In the Middle Atlantic region, it is estimated that deterioration is following cutting on 90 percent of the forest land currently cut over. That is, the stands which follow cutting on some 330,000 acres will mature a smaller volume of valuable material than that just cut, or will take longer to mature it. On the other hand, some areas cut clean for chemical wood or other products have restocked with an excellent young stand in which desirable species such as cherry, ash, and hard maple are well represented. Where deterioration is present, it is due very largely to failure to make any provision for seedling reproduction. The forest on private land is often cut before it has reached an age to produce seed in appreciable quantities, and regeneration is overwhelmingly of sprout origin on hardwood lands. Rate of growth is known to be less over a tree rotation for sprouts than for trees of seedling origin, and some species (the oaks, for example) are subject to serious heartwood decay entirely independent of fire injury. The total effect of dependence on coppicing is in general a widely spaced, slow-growing, defective stand, and this effect is increased by repeated cuttings.

In the South, 10,000 acres of second-growth river-bottom hardwoods and cypress lands in south central Louisiana present an example of "high-grading" a stand by removal of the best trees. An examination of these lands some time after the original stand was removed showed the composition of the present stand to be as follows:

	Number of trees per acre
Potentially valuable trees	166. 58
Trees ready to be cut	2. 91
Cull trees	75. 52
Total	245. 01

The "potentially valuable trees" are the trees which will be present in the stand after 20 years, but in larger diameter classes. The "trees ready to be cut" are the merchantable trees that will be removed when economic conditions permit. The "cull trees" are trees which because of poor form, decay, or quality are unmerchantable. Culls make up 31 percent of the total residual stand. In other words, through past cutting this stand now includes a volume of defective material sufficient to displace more than one third of the production which could be secured if the growing stock were all of vigorous and well-formed trees.

This 10,000-acre sample is reported to be more or less typical of 25 percent of the total area of cut-over river-bottom hardwood and cypress lands, or some six million acres.

IN CALIFORNIA AND SOUTHERN SOFTWOOD STANDS

In the California pine region, logging methods destroy an unnecessary amount of advance reproduction and immature trees; failure in many instances to leave sufficient seed trees, results in understocked stands of young growth; and in other cases the removal of the pines from mixed stands leaves a growing stock consisting chiefly of defective and unmerchantable white fir and other low value species. The last condition is brought out strikingly in table 8 compiled from an inventory of an area tractor-logged in 1930, which shows how the removal of the pines has converted a mixed stand into a stand in which white fir, chiefly unmerchantable, predominates and in which the quality growth capacity of the stand has been materially lowered.

In the redwood region of California and in the Douglas fir region of Oregon and Washington, the effects of fire and logging are so closely associated that no attempt is made to separate them. Deterioration in these stands has been discussed under Effects of Fire.

TABLE 8.—*Comparison of original stand with residual stand on an area tractor-logged in 1930—California pine region*

Diameter class	White fir		Incense cedar		Douglas fir		Sugar pine		Ponderosa pine		All species	
	Trees per acre	Volume	Trees per acre	Volume	Trees per acre	Volume	Trees per acre	Volume	Trees per acre	Volume	Trees per acre	Volume
	Number	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*
ORIGINAL STAND												
0 to 4 inches	12.0	--------	3.5	------	8.5	--------	1.0	------	1.0	------	26.0	--------
6 to 14 inches	29.5	431	4.0	33	13.5	243	3.5	152	5.0	159	55.5	1,018
16 to 20 inches	7.0	1,910	2.0	222	3.5	978	1.0	205	1.0	232	14.5	3,547
22 inches and over	11.5	15,492	0.5	213	9.0	16,013	3.0	5,191	2.0	5,130	26.0	42,049
RESIDUAL MERCHANTABLE STAND												
0 to 4 inches	5.0	--------	1.5	------	3.0	--------	------	------	0.5	------	10.0	--------
6 to 14 inches	13.5	305	1.5	11	9.0	243	2.0	123	1.0	80	27.0	762
16 to 20 inches	4.0	1,098	0.5	34	2.5	718	1.0	205	------	------	8.0	2,055
22 inches and over	1.5	817	------	------	------	--------	------	------	------	------	1.5	817
RESIDUAL UNMERCHANTABLE STAND												
0 to 4 inches	7.0	--------	2.0	------	5.5	--------	1.0	------	0.5	------	16.0	--------
6 to 14 inches	15.0	126	2.5	22	4.5	--------	1.5	30	4.0	80	27.5	258
16 to 20 inches	3.0	812	0.5	55	1.0	259	------	------	1.0	232	5.5	1,358
22 inches and over	8.5	13,586	0.5	213	2.5	4,890	0.5	539	------	------	12.0	19,228

In the ponderosa pine forests east of the Cascades in Oregon and Washington, logging methods on private lands have the same tendency as in the California pine region to increase the representation of the less desirable species (fir and larch in this instance) at the expense of pine and to leave an insufficient residual stand to produce full crops.

In Idaho and Montana, the present practice of removing all the pine sawtimber and cedar poles from the old growth saw-log stands in the western white pine type leaves a residual stand much depreciated in quality, character, and value. In many cases the land will be left in possession of nonproductive, defective western hemlock and white fir. It is estimated that one third to one half of the private timber lands cut over annually is so logged as to impair the quality, character, and value of the coming crop.

In the South, many thousands of acres of pinelands are deficient in stocking because of failure to leave sufficient seed trees. Skidder logging of old growth longleaf stands leaves few trees either good or poor. Slash fires complete the destruction, and seedlings surviving are often destroyed by hogs.

The mixed shortleaf, loblolly, and hardwood stands of the upper coastal plain and lower piedmont, particularly in Alabama, Mississippi Louisiana, and Arkansas, have been subjected to a series of cuttings which in many stands removed first the pine sawtimber, later the pine poles, and finally the pine pulpwood. The remaining stand consists of poor and defective hardwoods, chiefly low grade oak, gum, etc., and is of little value. Reproduction of the pine is hindered by hardwoods which rapidly occupy the ground following cutting. Over many thousand acres the productive capacity of the land is reduced to a fraction of its possibilities.

The pulp industry, although of relatively recent origin in the South, is already responsible for the premature cutting of considerable areas of young growth. Such stands are destroyed at the beginning of the period of greatest production of values, leaving the forest owner practically no return for the use of his property. If, on the other hand, material suitable for pulp were removed in thinnings, the stand would be greatly benefited and the owner would be compensated by the production of higher priced material to be cut later.

CONCLUSION

As a result of present cutting methods and fire, the growing stock on more than 850,000 acres is destroyed completely each year, and at least 36 million acres are subject to deterioration in quantity and quality of yield. Out of a total of 495 million acres of commercial forest land, not less than 275 million acres which have been cut over one or more times are producing only a fraction of their normal capacity. Indications are that current devastation may be offset by the establishment of new forests on areas long ago devastated, but the loss from deterioration can only be compensated as silvicultural practice and fire protection are extended and intensified on forest areas in all regions.

Deterioration is far more important than devastation. The almost universal abandonment of cut-over land to harmful influences, or further mistreatment, is resulting in lowered or complete loss of recoverable values over a much larger area than is devastated outright. Heavy cutting on critical sites, culling out of the valuable species, ignoring sanitation, no regard for reproduction or for uncut trees, no attention to growth, neglect of slash, inadequate protection against fires—these are handicaps no land can overcome unaided and produce good timber in paying quantities in reasonable time. The losses from reduced yields and long-deferred yields over very large areas will far exceed the loss over much smaller areas from complete devastation. Forests of partial stands, forests of inferior and defective species, can never be depended on to supply the demands for raw woods material in the important forest regions where these processes of deterioration are going on.

It is not enough to "keep the forests green." The scrub oak areas of the southern pinelands, the millions of acres of worthless aspen in the Lake States are "green", but this cover on large areas is worse than none since it prevents regeneration of more valuable species by natural means and increases, sometimes makes prohibitive the cost of planting.

The extension of organized fire protection and the tendency to leave trees of sizes unprofitable to log offer encouragement that the rate of forest deterioration may have reached its maximum. There is also a tendency, particularly on the Pacific coast, to abandon high-speed power-logging machinery in favor of less destructive and more economical types. These tendencies need to be accelerated.

Devastation and deterioration are essentially problems of private forest land ownership. Of the 10 million acres estimated to be cut over annually, not more than 175,000 are publicly owned or managed lands. Nearly 90 percent of all cordwood and restocking areas (including nonrestocking areas) are privately owned. Furthermore, public lands are for the most part, and to a continually increasing degree, cut with careful regard to the growth of a new timber crop. The investigation of the present management of private forest land holdings more than 1,000 acres in extent, made in 1930 by the Society of American Foresters and others, developed the outstanding fact that the remaining saw timber and cordwood commercial holdings on which an effort is being made to grow timber commercially compose less than one fifth of the total area of such holdings. The effects of a depleted growing stock on the opportunities of private forestry practice in this country are discussed in considerable detail in the section entitled, "Status and Opportunities of Private Forestry". It is sufficient to record here that the present growth on private forests is only a fraction of possible growth. This condition has been brought about by the management of private forest lands according to the tradition of realizing the maximum immediate return. This is not only inimical to permanent public welfare, but often contrary to the best long-time interests of the owner.

THE BREAKDOWN OF PRIVATE FOREST LAND OWNERSHIP[1]

By THORNTON T. MUNGER, Director, Pacific Northwest Forest Experiment Station

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This section shows that private forest land ownership in the United States is very unstable, that in certain parts of the country there is a breaking down of private ownership and the creation of a "new public domain"; it gives the evidences of this situation—tax delinquency and reversion, gifts and sales of land to the public at nominal prices; it describes the character of land involved, the causes for land abandonment, the trends and the problems created by this instability of ownership.

THE SITUATION

Of the 270 million acres of privately owned forest lands other than farm woodlands in the United States, a majority have no present or prospective commercial value except for timber growing or for the timber upon them. Most of the lands were acquired by their present owners for lumber, pulp, or naval stores operation or for speculation. Only 90 million of these 270 million acres (exclusive of farm woodlands) carry commercial saw-timber trees. Very little of the remainder—180 million acres—has been cut with any thought for the continued productivity of the land. On the contrary much of the land has been left without the nucleus either of a second crop or of seed trees, and has been burned and reburned. As a result, its value as a productive property has greatly depreciated and its return to satisfactory productivity is delayed and made more expensive. In some cases, the lumbering process has destroyed its potentialities for profitable timber production. In other cases, where the land might ultimately come into profitable production, the owner is just not interested in the long-time financing for future forest crops, and accordingly such land is considered by the owner as a liability.

Some cut-over land has been logged selectively, so that it retains its productivity and the prospect of yielding a reasonably early revenue; when this is the case there is much more interest on the part of the owner in retaining his title to the land. Some cut-over land has value for grazing, for game ranges, for minerals, for prospective agricultural colonization, for recreation, or for rights of way. These values create a different attitude on the part of the owner from that toward land that has no prospective value other than for forest production.

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[1] In the compilation of this section an unpublished manuscript by the Forest Taxation Inquiry of the Forest Service, Fred R. Fairchild, Director, has been drawn upon freely and phrases quoted verbatim. Acknowledgment is made to this agency for this valuable material.

In addition to the cut-over land which has been stripped of its commercial timber, some detached areas of uncut virgin timber or second-growth timber are considered by their owners as a liability which they would be glad to drop. Such lands were bought or taken under the public-land laws in the heyday of timberland speculation without due estimate of the cost of carrying them until they could be profitably exploited. Often they are inaccessibly located or carry an inferior quality of timber. Now their owners are land poor. Seeing no prospect of liquidating at a profit, they choose to abandon such lands, through the process of tax delinquency.

As a result of these conditions there are many millions of acres of private forest land in the United States to which the owners are no longer asserting title. Taxes have been allowed to go delinquent to the point of foreclosure and the lands have either come back definitely into the hands of the public or have such a fugitive form of proprietorship as to defeat any hope of timber growing. For example, in the three Lake States there is in the neighborhood of 10 million acres of such land; in the three Northwestern States of Idaho, Washington, and Oregon, upwards of 3 million acres; and for the eight Southern States the estimate is nearly 10 million acres; other regions add more millions of acres to this category.

The stability of private ownership is not uniform the country over. It differs in the several forest regions according to the condition in which the land is left after logging, the productive capacity of the land, its accessibility, the possibility of an early yield, the prevailing taxes, other carrying charges, and the local attitude of the owners.

This section is concerned with forest land, whether timbered or cut over, used primarily for forest purposes. There is in addition a great acreage of submarginal agricultural land in the forest regions on which agriculture has been attempted and failed; millions of acres have been abandoned in the last decade and much of it is reverting gradually to forest growth. This type of land is discussed in the section of this report, "The Agricultural Land Available for Forestry".

EVIDENCES OF THE BREAKDOWN OF PRIVATE OWNERSHIP

Evidences of the disintegration of private ownership of forest land, particularly of cut-over land, are very apparent in a number of the forest regions. The situation is not new. The abandonment of forest land by its owners has been going on for years. During the present economic depression the burden of carrying land has been very much aggravated, with the result that tax delinquency has greatly increased since 1929.

The breakdown of private forest land ownership is evident in various ways:

Tax delinquency.—For the purpose of this report land is considered delinquent when taxes are not paid when due. There is an enormous amount of tax delinquency the country over at the present time on all classes of property. It is rather important to distinguish between short-term and long-term delinquency. The former applies to cases where the owner is not in danger of losing his land; it may or may not be a premonition of ultimate tax reversion. Long-term tax delinquency, i.e., delinquency extending to near the legal time for tax sale, is obviously a symptom that the owner may not be able to, or does not wish to, continue to hold his land. When the delinquency accumulates to the time when the local law requires tax sale or foreclosure, it is an absolute evidence of the breakdown of private ownership, the first step toward conversion to public ownership. The appalling extent of tax delinquency for forest lands will be given later in detail for certain regions.

Tax reversion.—Is defined as the forfeiture of land to the State or county for nonpayment of taxes. This happens when the owner fails to sustain the burdens of ownership and no other private party is willing to assume them. Tax reversion may come in various ways and at various periods after initial delinquency, for the laws of the several States are very divergent on this point. In some, tax sale may take place immediately after the first delinquency, in others, after as long as four years. In some States foreclosure procedure follows three to five years after first delinquency, and either the town, county, or State takes title when there is no private purchaser of the tax certificate. The period during which the owner may redeem the land is likewise widely variable and in some of the States extends so long and is so liberally administered that actual forfeiture of the land is almost indefinitely postponed. Some tax delinquent land is acquired directly by individuals by buying tax certificates, and some is subsequently sold by the State or county after title has been obtained through foreclosure. The status of tax abandoned land therefore is in a constant state of upheaval; it may be technically forefeited to the State and yet actually be in private care, or it may pass from one private owner to another, or to the public, and then perhaps back to a private owner and later back to the public again. It may be bought at tax sale, merely to cut some remnants of standing timber, with no thought of permanent ownership, and again revert.

Donations.—In various parts of the country there has been some voluntary deeding of private forest land—mostly cut over—to the States. This has been done not so much from philanthropy, as from a desire to get rid of land which the owner thought uneconomic to hold. There have been furthermore many overtures by private owners to give to the States or the Federal Government forest land that could not be accepted because of poor title, legal restrictions, or other qualifications which the public could not accept. Recently there have been instances where tracts as large as 100,000 acres were offered in good faith as a gift to the Government. Certainly these donations and offers are a very eloquent indication of a breakdown in private land ownership.

Land exchanges and sales of private forest land to the public are frequently made when legislative provision for such transactions affords the opportunity. The Federal Government is authorized to exchange national-forest timber or land, or both, for private land inside—and in some cases outside—the national forests. Private owners have shown readiness, almost eagerness, to dispose of their cut-over lands, being more interested in having operatable timber than in holding cut-over or immature timber for a future cutting.

By such exchange 1,205,100 acres (gross) have been added to the national forests. The amount might have been much larger had it not been deemed inadvisable for the national-forest organization to make exchanges of stumpage for land to the extent of materially affecting the amount of national-forest timber-sale receipts that go to the counties.

Likewise there is a small Federal appropriation for purchase of forest lands for additions to national forests. In the last 20 years some 4,727,680 acres have been so purchased. The acreage of such lands offered far exceeds the area that can be purchased, and it is significant that the price at which sales are consummated is progressively diminishing. In the East, millions of acres are available for purchase at half the price of a few years back, making them very favorable buys for public ownership. In recent years there has been a gradual falling off in the price asked, which has latterly become precipitous. In one western region well-stocked cut-over forest land is being offered for sale in increasing quantities at 25 to 50 cents an acre. In another western region tracts of 100,000 acres and more are being offered at prices half of what they were held for a few years back.

In addition to the activities of the Federal Government in taking private land by purchase or exchange, some of the States, notably New York and Pennsylvania, have been active on a large scale in acquiring private forest land for State forests.

This willingness of owners to dispose of their forest land on a "buyer's" or "distress" market, so to speak, is another very definite evidence of the breakdown of private ownership. It is especially significant because some of these lands are well stocked and have genuine promise of being profitable properties under public ownership. It is much in the interest of the public to have them protected and kept productive for the many benefits they will give, even if the owner sees no benefit to himself in retaining title.

Mortgage foreclosure and bankruptcy are responsible for a considerable shifting of rural ownership, and a good deal of land has gone into the possession of the Federal land banksand private banks in this way. In the years 1926 to 1929, inclusive, in the whole United States 17 farms per thousand changed ownership through foreclosure of mortgages, bankruptcy, etc. There was no tendency toward increase in that period, but since then the depression has accounted for some acceleration. No data are available on the foreclosure of forest land per se, but in the forest regions a very material part of the mortgaged farms are woodland. This large amount of mortgage foreclosure is due principally to deflation of land values accompanied by inability of the crop returns to pay fixed charges, but it is also a sympton of the instability of land ownership and applies to forest as well as farm property.

EXTENT OF TAX REVERSION AND DELINQUENCY

It is impossible to present complete statistics of the extent of tax-delinquent or tax-reverted forest lands in the United States. To do so would necessitate compiling the ever-changing delinquency lists for thousands upon thousands of different taxing units. Furthermore, in the few summaries that are available it is quite often impossible to separate forest land from other classes of realty.

Rather it becomes necessary to picture the tax delinquency situation for a few important forest regions that have been studied intensively. These examples of tax reversion and delinquency speak eloquently of the very real breakdown of private ownership in these several regions.

THE PACIFIC NORTHWEST

OREGON

In Oregon lands may be foreclosed by the county when three years delinquent if there is no tax certificate purchaser, and thereafter they become the property of the county, either to be sold or held. An act of the 1931 State Legislature makes it possible for forest lands to be deeded by the counties to the State for State forests.

Table 1 illustrates foreclosure and delinquency conditions in five counties that have recently been studied intensively. They are all in rather rough topography in the heart of the heavily timbered Douglas fir type of the northwestern part of the State, and have been and are now the seat of active logging operations characterized by absolute clean cutting and subsequent broadcast slash burning. A very little of the cut-over land is salable to settlers, and most of it is considered to have no prospective value for agriculture or any purpose other than timber production. In these five counties, out of 2,228,445 acres in the forest zone, 181,928 have already been foreclosed for taxes and are held by the counties. Nearly 200 thousand acres more were two or more years delinquent on January 1, 1931.

TABLE 1.—*Tax delinquency of lands in five typical northwestern Oregon counties in 1932*

County	Area under consideration [1]	Foreclosed for taxes [2]	Delinquent for taxes levied in [3]— 1927 and earlier	1928	1929	1930	Total [3]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Benton	322, 287	5, 493	15, 474	5, 384	14, 048	47, 987	88, 386
Clatsop	512, 629	34, 067	41, 312	16, 156	30, 853	244, 592	366, 980
Columbia	389, 951	19, 833	16, 385	15, 529	33, 693	98, 150	183, 590
Lincoln	451, 946	48, 911	33, 127	22, 257	51, 764	57, 777	213, 836
Tillamook	551, 632	73, 624	17, 919	11, 784	17, 755	125, 579	246, 661
Total	2, 228, 445	181, 928	124, 217	71, 110	148, 113	574, 085	1, 099, 453

[1] Mostly forest land, as studied; not the total area of the county.

[2] County owned.

[3] Amounts are not cumulative, but each represents delinquency commencing in the year indicated. All acreages shown were still delinquent in 1932; those paid up are omitted.

To indicate the progressive increase in both short- and long-term delinquency since 1921, the percentages of 1, 2, 3, 4, and 5 year delinquency within the forest zone of two of the northwestern Oregon counties are presented in table 2.

TABLE 2.—*Tax delinquencies from 1 to 5 years in Columbia and Clatsop Counties Oregon, 1921–30*

COLUMBIA COUNTY

Year of levy	First year delinquency	Second year delinquency	Third year delinquency	Fourth year delinquency	Fifth year delinquency
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
1921	10.3	7.3	4.9	3.6	1.7
1922	10.6	6.2	4.4	1.7	1.4
1923	12.8	7.9	5.8	2.0	1.8
1924	12.4	8.6	3.5	2.4	2.0
1925	14.2	6.1	4.1	3.3	2.6
1926	11.6	7.3	5.8	4.1	3.[illegible]
1927	11.9	7.7	5.5	4.9	
1928	13.9	8.2	6.2		
1929	20.1	15.0			
1930	35.9				

CLATSOP COUNTY[1]

Year of levy	First year delinquency	Second year delinquency	Third year delinquency	Fourth year delinquency	Fifth year delinquency
1921	15.4				
1922	16.9				
1923	15.7				
1924	21.1				
1925	19.2				
1926	22.3	17.5	15.7	15.2	14.5
1927	23.2	17.2	17.0	15.8	
1928	25.8	21.6	20.3		
1929	30.3	25.2			
1930	43.7				

[1] No data for years 1921–1925 beyond first-year delinquency.

First-year delinquency in Columbia County has progressively increased during the past decade, from 10.3 percent of the 1921 rolls to 35.9 percent of the 1930 rolls. Likewise 2- to 5-year delinquency shows a trend upward, and a notable increase in the delinquency in tax payments due the past year.

Tax delinquency and reversion in Oregon is not limited to the low value cut-over lands but extends even to merchantable timber, as will be seen in table 3, which gives the delinquency by land classes for the forested portions (i.e., excluding the urban and main agricultural zone) of two important timber counties of northern Oregon.

TABLE 3.—*Delinquency in 1932 by land classes*[1] *in Clatsop and Tillamook Counties, Oregon*

CLATSOP COUNTY

Year of levy	Tillable land	Nontillable land[2]	Timber land[3]	Reforestation land[4]	All classes
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
1927 and earlier	488	14,196	23,036	3,592	41,312
1928	480	10,103	3,413	2,160	16,156
1929	601	9,807	13,252	7,193	30,853
1930	2,626	63,340	104,738	73,888	244,592
Total	4,195	97,446	144,439	86,833	332,913

TILLAMOOK COUNTY

Year of levy	Tillable land	Nontillable land[2]	Timber land[3]	Reforestation land[4]	All classes
1927 and earlier	123	10,469	7,327		17,919
1928	165	4,801	6,818		11,784
1929	524	9,129	8,102		17,755
1930	976	35,562	86,914	2,127	125,579
Total	1,788	59,961	109,161	2,127	173,037

[1] As classified for purposes of assessment.

[2] Cut-over land not classified as reforestation; stump pastures and other wild land not assessed for its timber.

[3] Land with commercial timber which is assessed in addition to the land.

[4] Classified as chiefly valuable for forest crops without mature timber in merchantable quantities.

No class of rural land, as shown by table 3, is exempt from delinquency and all classes show a sharp increase for the 1930 rolls. The amount of commercial timberland delinquent more than 1 year is small in comparison to that delinquent only 1 year.

Land delinquent 2 and 3 years has a high prospect of passing from private to public ownership. The very large amount of the 1930 levy delinquent for 1 year is due to three causes—the lowering in 1931 of the interest on delinquent taxes to 8 percent, the current shortage of cash in owners' pockets, and a "tax strike" or remonstrance against the port district taxes which are in litigation in Clatsop County.

The indications are, as a result of uncompleted local studies, that if present trends continue for the next 15 years private forest land abandonment will grow to the amount of 1,000,000 acres in 5 northwestern Oregon counties (Benton, Clatsop, Columbia, Lincoln, and Tillamook). This is 43.5 percent of the forested part of these counties, the urban and major agricultural belt not being studied.

IDAHO

Northern Idaho was an almost continuous forest 35 years ago. Lumbering operations have now stripped off much of the commercial timber and large areas of cleanly cut-over land have been burned over. Some 300,000 acres, more or less, have gone into agriculture; but little more is destined to this use inasmuch as the rougher lands which typify the cut-over area have no such prospective use. Tax delinquency and reversion have been increasing at an alarming rate, a striking, clear illustration of the breakdown in private forest-land ownership, despite tax relief legislation for immature stands enacted nearly 4 years ago. A statistical picture of the situation in the five North Idaho counties (Benewah, Bonner, Boundary, Kootenai, and Shoshone) is presented in table 4.

TABLE 4.—*Tax foreclosure and delinquency in five North Idaho counties 1927, 1930, and 1932*

[In thousands of acres]

Year	Total area [1]	Foreclosed [2]	Delinquent 3-4 years	Delinquent 1-2 years
1927	2,164	3	46	
1930	2,156	55	101	
1932	2,136	123	131	292

[1] Other than urban and national forest.

[2] County-owned.

Here in 5 years the tax-foreclosed, county-owned area has increased from 3,000 to 123,000 acres, out of a little more than 2,000,000 acres of rural land. The 3- and 4-year delinquent acreage has likewise grown from 46,000 to 131,000 acres.

WASHINGTON

A study of Pend Oreille County in northeastern Washington, contiguous to the North Idaho counties just described, gives a striking illustration of the process that is taking place in the once heavily timbered regions of private ownership, now largely cut over and for the most part burned after cutting, where but little of the land has potential uses other than timber growing. The area of public ownership is already large and clearly is growing larger.

TABLE 5.—*Ownership and delinquency of land in Pend Oreille County, Wash., 1932*

Ownership or delinquency	Area	
	Acres	Percent
Area of county in forest outside national forest	287,389	100
Public domain	43,498	15
State-owned	14,575	5
County-owned (through tax foreclosure)	52,335	19
Delinquent 3–5 years	39,400	14
Delinquent 1–2 years	29,560	10
Small-owner acreage tax delinquent		49
Large-owner acreage tax delinquent		21

Of the total delinquent area not foreclosed (68,960 acres) 35 percent is 5 years delinquent, 11 percent 4 years, 12 percent 3 years, 18 percent 2 years, and 25 percent 1 year, showing that the serious delinquency situation is of long standing and not the result of the current business depression.

LAKE STATES

The northern portion of the Lake States was at one time an almost continuous forest of conifers. Extensive lumbering operations followed by repeated fires have wiped it almost clean of merchantable timber and left much of it in a wholly unproductive condition.

Although the bulk of the forest land in the Lake States is now in private ownership, a revolutionary change in the situation seems to be imminent. This is evident in the extensive tax delinquency in the cut-over counties and by the failure of any considerable number of owners to take advantage of the reforestation tax laws aimed to keep land in private hands for timber growing. From 18 to 20 million acres of forest land is delinquent and virtually abandoned, a "new public domain" embracing 35 percent of the forest area of the three States. It is predicted that if the present trend continues for another 10 years practically 50 percent of the forest area will be in public ownership.

The widespread tax delinquency in the northern portion of the Lake States is largely due to using the natural resources without thought of continuous production, resulting in the closing down of industries dependent upon wood and a consequent enormous shrinkage in taxable values. It is due also to a considerable extent to a wrong appraisal of future trends in agriculture which has resulted in the colonization of land unsuited to agriculture and the expenditure of large sums of public money for roads, schools, ditches, etc., in the belief that most of the land would soon be taken up in farms.

In Wisconsin are some 16 million acres of commercial forest land, or close to one half the total area of the State. Except for possibly a half million acres of virgin forest in the northern part and another half million in the south, all are cut over and badly burned. The half million acres in the south are in farm woodlands. In the 16 northern forest counties of Wisconsin it is estimated that there is now 5 million acres involved in delinquency, of which 4 million acres is forest land. By the end of 1931 about 685,000 acres of forest land had been tax forfeited, which is about three times that forfeited up to 1927. Under present legislation, and with present trends in tax delinquency, possibly 6 million acres may revert to county ownership in the next 10 years.

Michigan as a whole had 9,114,000 acres tax delinquent in 1929, of which over two thirds was in the forest and mineral counties. The area grew in the forest counties between 1910 and 1928 from 3,271,000 acres to 6,211,000 acres and likewise the acreage advertised for sale in the forest ounties increased from 1,308,000 acres in 1910 to 2,962,000 acres in 1927. In Michigan about 250,000 acres of tax title land are being deeded to the State each year for State forests; however, delinquency is increasing to even a larger extent than this, attaining some 400,000 acres per year. But the State, for various reasons, is not asserting title as rapidly as the land becomes technically available. Up to the present time title to about 1,250,000 acres of forest land has passed from private to State ownership—a very considerable proportion of Michigan's 19 million acres of commercial forest land.

In 15 forest counties of northern Minnesota, 18 percent of the total taxable unplatted (i. e., nonurban) area was delinquent 1–3 years in 1928, and 13.9 percent was delinquent more than 3 years. This means more than 1,500,000 acres delinquent more than 3 years and more than 2,000,000 acres for a shorter period. Land that has been delinquent for only 3 years has a chance of being redeemed by the owner. Land that has been delinquent more than 3 years may be considered permanently delinquent and only needing the official act of the State to transfer it to public ownership. More than one fourth of the taxable area of two counties has reached this latter stage.

Since the above figures were compiled, delinquency has continued unabated, but the State has not yet taken title to any of these lands. It is understood that it will take title to over 4,000,000 acres in 1933 when a recent legislative provision becomes effective. This is a fifth of the State's commercial forest area. In 16 northern Minnesota counties in 1931 there were 6,830,840 acres involved in some degree of delinquency or 46 percent of the total taxable area of these forest counties; of this 4,039,280 acres is delinquent for taxes levied since 1926 or prior thereto, and is deedable to the State.

SOUTHERN STATES

The southern pineries have been the scene of very active and extensive lumbering for the last three decades or more. The forest has usually been heavily cut and fires have run rampant thereafter. The forest values left on the land as the result of this destructive logging are, from the point of view of the "cut and get out" lumber owner, very little. However, some timber owners, both large and small, are very definitely holding their lands for continuous production of timber or, in the longleaf- slash pine type, for naval stores in conjunction with timber. This is in addition to the large acreage of farm woodlands where the forest is used with the arable land.

It is obvious that land ownership is in a very unstable status in the forested territory of the South, but it is difficult to appraise the present stage of the breakdown in private ownership or predict its trends. Laws are so designed, or so loosely administered, as to keep land from coming into public ownership, even though there may be a rapid turnover of private ownership at tax sales. The problem is complicated by the fact that the climate and topography create an exaggerated hope of colonization by settlers on cut-over land. This and prospects of oil or minerals give a speculative value that encourages private retention of the lands, temporarily at least.

In 8 southern States (Florida, Arkansas, Louisiana, Mississippi, Texas, Oklahoma, Alabama, and Georgia) there has now fallen into the possession of the State or county some 9,430,000 acres of commercial forest land, or 7 percent of the total forest area of the region. The area delinquent for 1930 and 1931 taxes, which has not yet reverted, is estimated at 4,220,000 acres, or 3 percent, of the total commercial forest area. The 8 States rank in amount of delinquency in the order given above. Whether or not these areas will remain in public control cannot be predicted; in some of the States, notably Florida, landowners do not consider these lands reverted to the State, but expect to recover title. Furthermore, some, if not most, of the States have no policy or legislative authority for holding this land in public ownership if it can possibly be restored to the tax rolls.

In Florida, prior to 1925, tax delinquency was rare; since then it has grown by leaps and bounds and in 1929 and 1930 tax sales amounted to about 7 million acres each year. This means that less than 80 percent of the property taxes levied were collected without resort to sale, an extreme situation resulting from the collapse of the land boom and dissatisfaction with tax levies. This is for all land, but most of the acreage is forest land, chiefly in large blocks and more than half in corporate ownership. In 1928 it was reported that 5,900,000 acres had reverted to the State, and the Florida Land Owners' Association estimated on October 30, 1930, that over 7 million acres, or one fifth of the land area of the State, had reverted for chronic nonpayment of taxes. How much of this will be redeemed by the original owners, or sold, or held in public ownership, is problematical.

Mississippi, in 1931, had matured title to approximately 275,000 acres of tax-title land. In April, 1932, 7,000,000 acres, mostly forest land, were sold for unpaid 1931 taxes, one quarter of the total land area of the State. It is estimated that 1,000,000 acres of this was struck off to the State, the rest bid in by private parties. Of this 1,000,000 acres, much may be redeemed and probably a minority amount remain in public ownership.

Louisiana, in the period 1925 to 1930, inclusive, 535,379 acres in rural Louisiana (forest and farm property) were certified to State ownership—a net area, after allowing for all redemption, cancelation, and duplications. From 1925 to 1927 there was a decrease in the reverted acreage, but it rose thereafter and in 1930 took an enormous jump in spite of the average assessed valuation being less than in any year since 1925. However, the prospect of oil has apparently been a check on reversion in this and some of the other Gulf States.

Alabama is reputed to have very little delinquency or at least very little that advances beyond the point of advertising. The explanation is probably a comparatively low rate of taxation and a prospect of oil or mineral wealth beneath the soil.

In Arkansas as a whole, in 1927, 5.3 percent of the total locally assessed realty valuation was delinquent. In 1931 this was more than tripled, reaching 16.6 percent. The forest area that is estimated as reverted to public ownership as of 1932 is 1,120,000 acres; in addition there are 800,000 acres of forest land delinquent but not yet reverted to the State.

Texas reports no long-term delinquency, for the reason that most owners prefer to keep their taxes paid up to protect their equity in oil or mineral rights.

OTHER REGIONS AND STATES

The above account gives a picture of the situation in several of the major forest regions of the country for which information on delinquency and tax reversion is available. The regions with great areas of cut-over land, much of which is useful for nothing but forest production, like the Lake States, the South, and the Northwest, or with areas of inaccessible or unmarketable private timber, like the Northwest, face the problem whether private or public ownership will prevail on a gigantic scale, a problem not encountered in those States where the forest lands have other uses after the virgin timber is removed, where conservative cutting has been practiced, or where the forest is associated with agricultural use.

In the Central States (Ohio, Indiana, Illinois, Iowa, and Missouri) the breakdown of private forest land ownership concerns largely farm woodlands and waste lands, since it is in this class of ownership that most delinquency occurs. The area actually reverted to public agencies in the Central States, as in the South, does not present a true picture of the marginal-land problem, largely because of the delinquency procedure, and the association of these submarginal lands with more valuable lands. The practice of purchasing tax titles before their forfeiture occurs is common practice. Thus, lands which are submarginal for farming are acquired by successive owners for the period provided by the State laws. In this way lands do not revert to county or State, but pass from one owner to another as they fail to make returns sufficient to meet tax assessments. In many instances, where tax-delinquent land has no sale, the county allows the title to remain with the original owner, rather than take it over to county ownership. In some sections there is so much submarginal land becoming tax delinquent that local government is entirely incapable of handling the situation.

In Virginia a rough estimate places the area of delinquent lands which could be put into forest use at 2,220,000 acres, counting 1,200,000 acres of waste land which formerly bore timber and is capable of doing so again, and 1,000,000 that are described as idle crop land. Much of the latter class has been so eroded by attempt to farm hilly land by tenant farmers that it is unfitted for further farm cropping, a situation common throughout the piedmont.

In North Carolina an estimate of the permanently delinquent land for the eastern piedmont and coastal plains region is 8 percent of the total forest-land area and 5 percent of the total cleared-land area. These percentages applied to the rest of the State indicate more than a million and a half acres of forest land and nearly a half million acres of cleared land as ready for reversion. Tax delinquency is increasing, and this year more than a quarter of all property in North Carolina will be advertised for taxes; but most of this will be redeemed before sale. So far there has been no reversion of delinquent land to the counties, but the fact that tax-sale certificates have in the past nearly always been redeemed is no proof that they will continue to be.

In New England nowhere is the tax-delinquency problem acute, and there has been practically no reversion of land. A type of forest and a method of cutting which have left the land with some prospects of future forest productivity, favorable taxes, accessible markets for forest products, and a disposition on the part of both the owners and public agencies to keep the lands in private hands, have all contributed to this situation.

It is roughly estimated that in Pennsylvania a little more than a million acres of forest land is delinquent out of a total of 11 million acres of commercial forest privately owned; possibly a half million acres will be unredeemed and be added to the "new public domain." In some instances the county has taken title to as much as 5 percent of the area outside farms. One reason why there is not more forest land abandonment is the fact that about 60 percent of the State's private forests are held for subsurface rights and some are also valued for hunting preserves as well as for forest production. A further reason is the fact that the cutting practices, particularly in the sprout-hardwoods forests, have not altogether destroyed forest productivity; some potential forest value is left which encourages the owner to retain title.

In New Jersey the township may sell for accrued taxes or give to the State Department of Conservation tax-title lands, and 10 thousand acres were so sold in 1930 and 1931 for State forests. In the "pine barrens" of southern New Jersey it was found in 1917 that 40 percent of the land area of some townships was not on the tax roll—truly a "no man's land."

In Maryland, Delaware, Georgia, the Virginias, and the Carolinas, no reversion of land appears to have occurred up to the present time; but the volume of delinquency is increasing and some reversion seems imminent.

In California timberland tax delinquency is not large up to the present time, but has increased during the depression. In the productive redwood region on both timberland and cut-over land there is very little delinquency. There is more in the pine region, where for five selected counties about a fifth of the private forest land is delinquent. This is mostly made up of small areas in the Sierra foothills, formerly forested, but now with but a mere remnant of forest growth upon them; it is now repeatedly burned in the hope of improving stock grazing, for which it is principally used. With millions of acres of low-value land in private ownership, and abandonment in its incipient stages, there is the threat of a breakdown of private ownership on a large scale in California.

THE CAUSES OF FOREST LAND ABANDONMENT

In considering the causes for tax delinquency and tax reversion of forest land a distinction must again be made between short-term and long-term delinquency. Short-term delinquency may or may not lead to longer delinquency and ultimately to forfeiture of the land. Short-term delinquency may be due to procrastination of the taxpayer, faulty collection methods, or temporary financial embarrassment of the owner.

It is with long-term delinquency that this discussion is concerned, the delinquency that results in abandonment by the owner, and indicates a breakdown from private to public ownership. Such long-term delinquency in the case of forest land can be said to be mainly purposeful—that is, the owner deliberately ceases to pay his taxes because he would rather forfeit the property than pay the annual carrying charges. This is, of course, true in varying degrees; if the taxes are very low (in proportion to the true value of the land for any purpose) he may be more inclined to hold on even to the most unpromising land than if the taxes were high. There are many gradations between the type of land which the owner decides he has no desire to retain and that which he would like to keep for its prospective value but on which he is unwilling or unable to pay the tax.

CUT-OVER LAND

The most fundamental and underlying cause for the delinquency and abandonment of much cut-over land is that it was acquired by lumberman owner not as property to be cropped in perpetuity, but rather merely for its virgin timber values. After these were taken off, the naked land by itself was of no interest to him. The tradition of the American lumber industry has been "to cut out and get out"—an outgrowth of the once prevalent impression that the virgin timber supplies of the country were inexhaustible and of the very low prices at which virgin stumpage could be bought. The public land laws and the early policies of the States and Nation made easy this practice of stripping off the virgin timber in one region and moving on to another. The unwisdom of this, not only from the point of view of the public but from that of the private owner who might have benefited in the long run by a sustained-yield policy of management, is becoming more and more apparent. A question raised very sharply by this breakdown in private ownership is whether the whole conception of transferring to private ownership so much forest land was not in error. In the public-land States there was acquired for private ownership in a comparatively few years an area of virgin timberland which the owners were wholly unprepared to hold and manage conservatively. This is discussed further in the section, 'The Probable Future Distribution of Forest Land Ownership".

A contributing cause for the delinquency and abandonment of much cut-over land is that its forest productivity has been wrecked in the process of logging. Land left in unproductive condition and subject to repeated fires is very unattractive for private ownership. There is an enormous acreage in this category. Had this land been logged with thought of the future under sustained-yield principles, had seed trees been left and slashings carefully disposed of, this situation of land abandonment would not be so acute. Forest productivity would be unimpaired and permanent private ownership might have been attractive. The situation is analogous to that on agricultural lands on which farming methods in use have depleted the fertility of the soil or allowed it to erode to the extent that the land has become unproductive and is abandoned by the owner.

There is delinquency also in land left in productive condition, simply because the owner sees no profit in holding the land for another crop or takes no interest in permanent forest-land management. Here there is apparently a correlation between the extent of delinquency and the amount of the taxes, other things being equal. The higher the taxes the greater the extent of the delinquency. Taxes that are out of proportion to the earning power of the property, present or prospective, portend delinquency and foreclosure. A deflation in property values, due to the disappearance of supposed speculative values, or to an economic depression like the present, and not accompanied by commensurate tax reduction, stimulates the abandonment of land. Forest land that is exposed to colonization development, with accompanying mounting costs of Government for roads and schools, becomes subject to a growing tax burden from special levies of one kind and another. When a certain limit is reached, the owner of cut-over land decides he can not afford to hold on longer and abandons his property, which may fall to public ownership or may be taken up by another class of owner for other purposes.

It is not only the actual present taxes that deter an owner from holding his cut-over lands but the apprehension that his taxes will be raised to the breaking point before he can get any return from subsequent forest crops.

It is quite significant that in the forest district of northern Maine, where there is a disposition to hold lands and keep them productive, where town Government is not organized, governmental facilities are few, and taxes are correspondingly low, there is practically no tax delinquency, even though there are great areas of logged lands. The fact that much of these lands are logged selectively, fires are held down, and forest productivity is preserved gives the owner a permanent interest in the land that impels him to be willing to pay a reasonable annual tax.

It was found in Minnesota, and the same condition probably prevails elsewhere, that long-term delinquency was higher in cut-over forest counties where attempt had been made at agricultural development and found to be unsuccessful, than in counties where agricultural settlement was not attempted. Apparently, in regions where settlement takes place, tax levies and assessments rise on account of roads, schools, etc., on even the unoccupied interfarm areas. This discourages the owner of idle cut-over land from further tax paying. As these latter lands go delinquent the tax burden is then shifted to the owner of the submarginal agricultural land, who in turn becomes desirous of abandoning his land because its production does not justify its growing tax burden. The process of tax delinquency is thus self-accelerating and the breakdown of private ownership pyramided as the process continues.

UNCUT TIMBERLAND

The amount of mature timber, not considering farm woodland, which is reverting from private to public ownership is apparently not large at present; it is greater in the Northwest than elsewhere. Where there is tax foreclosure on mature timberland that has an intrinsic value to justify its carrying charges, the cause must be sought in the inability of the present owner to pay his taxes even though he wants to hold the land. In this case it is to be expected that there will be a private purchaser for this land and that it will not go into public ownership before the timber is removed.

However, there is some private timber in the Northwest so inacessible for immediate exploitation that to carry it until it becomes "economically ripe" may be unjustified for a private owner in the light of present stumpage price forecasts. Appreciating this fact, certain owners, mostly small and financially weak, are recognizing that a poor speculation was made and are abandoning their investments. Land of this category is likely to revert to public ownership, unless there be much greater optimism in timber speculation than at present, or unless the counties or the States make extraordinary provision to get the land back on the tax rolls.

In California, Oregon, Washington, Idaho, and some other States, a compulsory fire patrol law requires the owner of forest property to protect his land, otherwise the State does so at his expense. When an owner abandons his land, he escapes not only the taxes, but also the burden of protecting it; this must be considered in explaining the reasons for permanent tax delinquency. In the above-mentioned States the current liability for fire patrol may amount to as much as the taxes on cut-over land or more.

THE REASONS WHY SOME LAND IS NOT GOING DELINQUENT

There is a considerable cut-over forest acreage which, by comparison with land of similar physical conditions and tax burdens, should be tax-abandoned but is not. Its actual value for forest production in the condition in which it has been left does not apparently justify its carrying charges, yet its owner continues to pay the taxes. It may be said to be in the balance between private ownership and reversion to the public. Some of this is now in private ownership purely because of temporary considerations and will almost surely go delinquent; other areas may or may not stay in private ownership depending upon the trend of tax laws, economic developments, etc. Some of the considerations postponing or preventing abandonment of land which could be expected to be delinquent are as follows:

1. The value which cut-over land contiguous to active logging operations may have to the operator for rights of way and for control of his property as a unit.
2. The fact that failure to pay taxes on cut-over land may have the effect of increasing taxes on adjoining standing timber, with no net gain to the owner and a possible danger of incurring disfavor with the taxing authorities.
3. Hope that land hunger may make a market for the stump land, if it has any agricultural or any form of recreational possibilities.
4. Speculative possibilities that oil or minerals may be found beneath the stump land.
5. The chance that the Federal or local government, as a part of a program of expanding public forests to safeguard the future timber needs of the people for watershed protection, etc., may desire to acquire these lands either by exchange or purchase.
6. A faith in the future that, where the land has been left reasonably productive, the ultimate value of stumpage will justify holding

it, even though the young growth has practically no market value at the present time.

7. The requirements of mortgage notes that may preclude abandoning parcels of an entire tract.

8. Use of the land for grazing.

The first two considerations are transitory. It may be expected in some of the major forest regions that when a logging operation is concluded in a county the entire tract of logged land will be abandoned. This seems to be borne out by the history of some of the logging centers. As a higher percentage of the country becomes logged, delinquency is greatly accelerated.

The third reason—hope of sale for agriculture or recreation—will vary with the region and with the pendulum of human tastes and business trends. Colonization has already been carried so far and so unsuccessfully on stump lands decidedly submarginal for agriculture that the trend in the Northern States seems to be away from further hope of profit from such use of forest land. In the Lake States extraordinary recreational uses, and in the Southeast hunting facilities, furnish a prospective additional return from certain classes of forest land that might otherwise go delinquent, but whether these uses, supplemental to forest uses, will be sufficient to hold in private ownership any great amount of land, otherwise tax-forfeited is problematical.

The speculative possibility that minerals or oil may be found, or that the public will acquire the land by exchange or purchase, is undoubtedly holding some land, temporarily at least, in private hands. These reasons prevail more or less in all parts of the country, but certainly the oil prospects are a material reason why there is not more delinquency in such States as Louisiana and Texas.

Faith in the future of reasonably productive land may often cause one owner to hold his land even though his neighbor with identically the same kind of land under the same economic conditions, adopts the policy of abandoning his. So long as his land is in productive condition, the former owner has hope of the ultimate profitableness of holding his property.

Grazing rental of cut-over land, particularly as found in the Rocky Mountain States, helps to carry the land and forestall delinquency. Such land is often sold by the timberman for grazing use, and so remains in private ownership primarily for range purposes, not timber growing, though the two purposes may both be served in the long run.

FACTORS THAT DETER THE CONVERSION FROM PRIVATE TO PUBLIC OWNERSHIP

Much of the low-grade and cut-over forest land of the country, as well as much submarginal agricultural land, is in a very unstable status, lying suspended, so to speak, between the private owner and the public. The private owner does not want it. The public has not the policy or the legislative program to hold and manage it. For this reason the statistics of the acreage of tax-reverted land give but a partial picture of the seriousness of the breakdown of private ownership. They do not include the great acreage which is in reality abandoned by its owners but to which the public is not asserting title.

This is land which in last analysis is in the mind of the owner not thought to be sufficiently promising of yields in the present condition to be economic to hold. It presents a very serious legislative and economic problem, because, although it is counted upon in the budgets to yield a tax revenue, it pays taxes only intermittently if at all. Either there is no provision or only inadequate provision for its management and protection from fire and it is therefore not only a liability but a menace to the community.

The reasons why such lands are held in this unsatisfactory and unsafe condition and do not immediately pass to public ownership may be chiefly summarized as follows:

1. It usually being the desire of local political units to keep land on the tax rolls, the laws are commonly framed with that end in view. Penalties for delinquency are not so severe as to be a real detriment; there is liberal provision for redemption by the original owner; delinquency, before the county can foreclose, is sometimes as long as 5 years (Washington). By sale of tax certificates, the land can go back into private ownership at much less than its assessed value. In many States an effort to resell the land after foreclosure is compulsory, and therefore so long as there are buyers at almost any price the lands cannot stay in public ownership. The now amended tax homestead law of 1893 in Michigan is an instance of the strenuous attempt to keep land on the tax rolls, even though it be not the kind of land that is economically sound for homesteading and could not permanently remain in private ownership.

2. Furthermore, the laws which in themselves favor retention in private ownership are commonly enforced with such laxity as to further favor private possession. Land is often not foreclosed until long after the statutory period and occupancy continues after legal rights of the owner have lapsed. The costly procedure of foreclosure is a further detriment to prompt execution of the tax-delinquency statutes.

3. In the absence of any definite policy and machinery on the part of the State or county for the management of public forest land, there is no incentive for the public to hold tax-title land. The tradition in most States has been to keep the land in private hands on the tax rolls. Where this is not the case, it becomes a "no man's land." It is little wonder therefore that tax-forfeited lands become a battledore to be batted back and forth between private owners and public agencies, often falling down between them and being picked up and used by neither.

In a few States definite provision has been made for the management of tax-reverted lands as State or county forests. This seems to be a remedy for the evils of the laissez-faire tax-reversion practices. Instances of such provisions are given in a later paragraph.

PRESENT PROVISIONS FOR THE DISPOSITION OF TAX-TITLE LANDS

The laws of the several States vary greatly as to the processes by which tax-delinquent land becomes forfeited and may ultimately become public property. The tax lien may be enforced in various ways and at various periods after delinquency. The most common ways (without going into the details of legal procedure) are the sale to anyone of tax certificates, automatic purchase by the State or county of the tax lien, foreclosure proceedings without sale of certificates, or some combination of these methods. After sale, a period is usually allowed during which the original owner may redeem his land, varying in the different States from a few months to three years—in New Jersey, 20 years if right of redemption is not foreclosed. After foreclosure and judgment there is usually no opportunity for redemption. To exercise redemption, the fees or penalties vary from rather moderate to quite large. Where the land is purchased at tax sale or through foreclosure by a private party and not redeemed before the redemption period has passed, a tax deed (or sheriff's or treasurer's deed) is issued, giving the new owner a title to the property. Where land is not sold to a private party or redeemed the title passes to the public. Of 34 of the principal forest States for which data is at hand, it appears that the title to the reverted land goes to the State in 15 States, to the county in 13 States, and to the town in 5 States. Other political units have equities in some States.

What is done with this "new public domain" after it has come into the possession of the State, county, or town? As previously stated, it is the policy in most parts of the country to get the land back into private ownership. Michigan attempted to do it by the tax homestead law of 1893, other States have sales, others lease the lands—even at rates less than the taxes would be. Where failure to find a buyer can be taken as prima-facie evidence that the land is not suitable for private ownership in its present condition and under the present economic set-up and tax policy, insistance on trying to get it back into private hands is most unfortunate. Instead, there should be some provision for putting such land under permanent public management. In a very few States such legislative provisions exist, with machinery for managing the land as State or county forests or parks. Some of these laws are here described briefly, by States, as examples of progressive steps to overcome the evils of this breakdown of private forest land ownership:

Michigan.—Tax-title lands go to the State and if suitable for State forests may be so dedicated, the State paying something to the counties in lieu of taxes. In this way Michigan has some 1,250,000 acres of State land, some of which is managed as State forests by the Department of Conservation, and this area is being added to at the rate of about 250,000 acres each year.

Wisconsin.—Here tax-reverted lands go to the county. Wisconsin has encouraged the development of county forests by permitting county lands to be listed under the forest-crop law and by providing State aid to the extent of 20 cents per acre. About 460,000 acres have been set aside during the past two years. Wisconsin also has State forests, acquired in part through tax delinquency.

Minnesota.—The conservation department has set as its aim the blocking out of about 4 million acres of State forests from tax delinquent lands in the next 10 years. Only a beginning has been made so far.

Oregon.—By provision of the 1931 legislature, tax-reverted land may be deeded by the county to the State to be managed as State forests in perpetuity, and the State will pay the county the forest fee and yield tax provided under the reforestation tax law. So far no lands have been so deeded for State forests. In at least one county tax-reverted lands are being held by the county with the purposeful policy of forest production.

Provisions for acquiring and managing State forests are found in many other States as well, but the above are the outstanding examples of legislation to put tax-forfeited lands under permanent forest management.

POSSIBLE FUTURE TRENDS IN TAX REVERSION OF FOREST LAND

The statistics of tax reversion are too incomplete to warrant making a mathematical prediction of the trend. Irrespective, however, of the acceleration of delinquency during the depression, the facts all point to an increase in land abandonment in the regions where the ownership is now unstable. Many of the factors which have in the past, and are now, creating tax delinquency and reversion are as potent as ever and in some regions certainly more so. Very prompt and radical action would have to be taken to nullify these factors.

In some regions there is an overburden of forest lands in private ownership; private capital took upon itself the ownership of an enormous amount of timberland merely to exploit the commercial stumpage with no contemplation of holding the lands permanently or managing them for continuous production; many people believe that there is much forest land that never should have gone into private hands. This basic factor of improper distribution of forest ownership is a continuing cause for the breakdown of private ownership.

It has already been shown that another basic cause for the abrogation of ownership is the destruction of forest productivity in the process of logging without thought for reforestation. Great areas in this condition have already gone delinquent, but even greater areas are still on the tax roll. In certain regions there is every reason to believe that an increasing acreage in this category will become "new public domain" unless very drastic steps are taken to stem the tide of tax reversion. So long as devastating logging continues, there will inevitably be lack of interest in permanent land ownership.

Delinquency of the lands which are in reasonably productive condition is affected by many conditions. With a diminishing timber supply, and with research, education, and extension teaching in forestry there is an increasing realization that timber growing will pay. In regions where the conditions favor early marketable yields, growth is good, and protection and other carrying costs are low, there will probably be a trend toward stabilized private ownership, but the outlook is that it will be slow in coming under the present regime.

There is a growing interest in timber growing by private owners. The very conception of sustained-yield forestry, which a few owners are adopting, presupposes permanent ownership. Selective logging will undoubtedly be practiced more widely in the future. This in tself insures land values that encourage permanent ownership.

There is much that the public might do to affect the stability or nstability of ownership. What the public in the several States will o is problematical. A strict enforcement of the delinquency laws would throw an immense acreage into the new public domain that is ow in uncertain status. A policy of allowing the public to take title, where now it is the policy to try to keep on the tax roll land unfit for private ownership, would also automatically put much land in State and county hands. A legislative program for the expansion of national, State, and other public forests would reveal how shaky private ownership is in some regions and would accelerate the transition from private to public ownership.

Whereas an increase in property taxes would tend to increase reversion, lowering taxes or fixing of taxes on growing timber, as has been done in some States, tends on the other hand to stabilize private ownership for at least the better lands.

Public assistance in forest protection or other measures of cooperation or subsidy that make forest growing more attractive to the owner are factors that would militate against the present high rate of reversion. On the other hand the withdrawal of such public aids to private timber growing as are now given would have the effect of accelerating land abandonment.

A general healthier economic condition in the forest industries would give timberland owners a confidence in the future, now lacking, that would increase interest in timber growing; this is to be expected in the long swing, but is apparently not an imminent factor in tax delinquency trends.

All in all it appears that tax delinquency and reversion can be expected to continue unabated for some years in the regions where they are now prevalent. An aroused public consciousness of the evils of the situation will hasten action to stem the tide of reversion or to correct its evils by properly taking care of the "no-man's land". With improvement in economic conditions for timber growing and acceptance of forestry principles, one of the basic causes for delinquency will gradually disappear, and in the rather distant future, with a wider distribution of public ownership, a more stable holding of private forest lands may be expected. Some States and regions will naturally work the problem out sooner than others, but if all regions begin at once, the solution of the serious problem of stabilizing ownership will be reached none too soon.

CONCLUSIONS

The great instability of forest ownership in the United States, which in some regions can be properly characterized as a breakdown of private ownership, points to the conclusion that there is a maladjustment of forest ownership—an unwise division between public and private property. In the western regions this has been the outgrowth of the public-land laws which put in private hands, within the space of a very few years, a great acreage that was not ready for economic use. The problem is basically one of correcting the defects in the distribution of forest ownership.

The situation has been intensified by the policies of the forest industries—under the duress of economic conditions—which have resulted in cutting the commercial forests without thought for the future and leaving a large part of their original area in an unproductive or deteriorated condition. Unfavorable tax systems and a mistaken idea of the future value of the land for agriculture have in some regions contributed to the situation. An acute risk of fire and the burning over by unchecked fires of great areas have made the land still more unattractive for permanent private ownership. The breakdown of private ownership is centered largely in clean-cut land, but some commercial timber and well-stocked immature timber is involved as well.

Present local political policy is generally wholly inadequate to solve this economic problem, though in a few States steps are being taken. There is a wide-spread policy to try to keep the land in private ownership by laws framed to that end or administered with a laxity that prevents delinquent areas from definitely becoming public property. This results in a great acreage of "no man's land" which private owners do not want and to which the public does not claim title, creating a serious problem of land idleness and of neglect and deterioration, as well as acute social and financial problems in the community.

In the process of abandonment, forest lands become more and more deteriorated, and more difficult and expensive to put back into production by whoever ultimately undertakes the job. This is one of the most serious consequences of instability of ownership.

The problems created by the breakdown of private ownership are many and complex, as are also the remedies, which are furthermore associated with other phases of the forestry enterprise. The solutions of the problem are discussed, along with those of interrelated problems, in other sections of this report and will therefore here be merely suggested by a brief formulation of the problem.

It is perhaps needless to mention the very obvious problem in public finance that is created by tax delinquency. Whenever taxes are not paid on a tract, the county, the school district, and the other taxing bodies must either trim their budgets or increase taxes on the land that remains on the rolls. Neither of these things are easy to do without causing distress, especially in the "backwoods" counties. Not only does land abandonment cut into county receipts, but it creates an expense for the care of these lands. The result in many instances has been county bankruptcy.

In a word, the crux of the problem is to get into stable ownership of some sort the forest lands of the country and to keep them there, so that they may be cared for and made productive. The approach to this end must be from two directions:

First. To stem the tide of land abandonment, so that land which is so physically and economically situated that it is proper for permanent private ownership will be protected and managed for continuous production. This will be primarily brought about on lands yet to be logged by encouraging the employment of such methods of forest management as will leave the land in good condition. Acceptance of the principles of sustained yield and of selective logging, backed up by more intensive forest protection, will automatically bring this about. To stem the tide of land abandonment on cut-over lands and immature timber a modification of present tax systems or proper application of present laws, where such land is now unjustly or illegally taxed, is indicated as one of the solutions. Zoning of areas predominantly suited for forest production by a broad land-use classification will help to stabilize ownershp, both of forest areas and of agricultural colonies, by concentrating schools, roads, and other services in areas where they are needed and lightening this expense and tax burden where they are not appropriate. Coincident with this it appears that further public assistance in fire protection would ameliorate the problem in some regions where the owner is not able to cope with the fires for which not he, but the general public, is responsible.

Second. To remedy the evils of tax abandonment by aggressive action on the part of the public to take care of the lands already reverted and those which will not stay inprivate ownership even if reasonable steps are taken to stem the tide of land abandonment.

For the lands which have already reverted or are in the unsettled status of "no-man's land" the public should make definite provision. This may mean revising the laws and procedure for foreclosures and public acquisition. It means that the public must squarely face the situation that a certain amount of land is not going to be on the tax roll and must adjust its local and State finances accordingly. It involves setting up the machinery to put these lands under management in State, county, or Federal forests, so that they can be protected, rehabilitated if necessary, and kept productive in perpetuity. This requires money which the public must be prepared to provide; this is sometimes difficult, for it comes on top of the loss of tax revenues, and where tax delinquency is worst the public finances are apt to be the lowest, but in many instances it is justified by the necessity for preventing greater deterioration and a chronic bankruptcy of the community.

For lands which have not reverted, but which are likely to, the public should anticipate the situation. A classification of forest areas by zones, differentiating between what should logically go into public control and what should remain in private hands, will give a planwise program for building a new public domain, instead of allowing a hit or miss breakdown of private ownership to continue.

The problem is not merely one of taking care of tax delinquent lands. This must be supplemented by a program of public acquisition, by purchase or exchange, for county, State, or Federal forest purposes. It should not overlook the desirability of acquiring lands before they have deteriorated in the process of abandonment or under terms which will prevent their devastation. Thus the public may be saved the delay and expense of rehabilitation, and the destructive and wasteful process of land abandonment may be forestalled.

STATUS AND OPPORTUNITIES OF PRIVATE FORESTRY

By BURT P. KIRKLAND, Principal Forest Economist

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PRESENT CONDITION OF PRIVATE FOREST LANDS

Forest productivity is governed by natural forces in much greater degree than by man's efforts. The better a region's climatic and soil conditions are adapted to the forest as a vegetative type, the greater the region's forest productivity. It is for this reason that even in the regions of the United States where settlement took place earliest and where, consequently, the forests have undergone exploitation for the longest period, private forest lands still yield considerable volumes of forest products. Data readily available show, unfortunately, that neglect and actual abuse of the forest resource under private control have reduced the productivity of this resource to a small fraction of what it might be. From the standpoint of national supplies of forest products the economic results of this reduction are not yet fully apparent, owing to the continued availability of considerable volumes of virgin timber. Locally and regionally, however, adverse economic results are apparent on every hand.

PRESENT AND POTENTIAL EXTENT

Probably the most enlightening way to approach the problems of private forest ownership is to consider the actual productive status of privately owned forest land in comparison with its reasonable possibilities. As a basis for such consideration the total area of privately owned forest lands of different classes and in different regions is shown in table 1. Privately owned forest lands are shown to have a total extent of 396,239,000 acres, and to be widely distributed, the greater part of the total area occurring in the eastern and southern regions. Table 2, showing the character of the forest growth on these lands discloses a distribution of forest supplies that contrasts with the distribution of the land itself; for example, the Pacific coast region, which as table 1 shows contains only about 8.4 percent of the private forest area, has about 60 percent of the privately owned standing timber.

TABLE 1.—*Amount and character of privately owned commercial forest areas of the United States* [1]

Region	Aggregate			Saw-timber areas			Cordwood areas		
	Total	Farm woodland	Industrial	Total	Farm woodland	Industrial	Total	Farm woodland	Industrial
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	25, 978	6, 402	19, 576	13, 261	2, 427	10, 834	4, 541	1, 700	2, 841
Middle Atlantic	24, 931	9, 461	15, 470	7, 200	3, 468	3, 732	9, 698	3, 613	6, 085
Lake	49, 073	14, 281	34, 792	4, 424	1, 793	2, 631	7, 833	4, 607	3, 226
Central	63, 477	32, 158	31, 319	20, 921	12, 158	8, 763	25, 368	12, 432	12, 936
South	187, 264	57, 866	129, 398	55, 220	13, 729	41, 491	52, 013	19, 789	32, 224
Pacific Coast	33, 037	5, 099	27, 938	18, 907	1, 740	17, 167	3, 098	928	2, 170
North Rocky Mountain	7, 338	1, 413	5, 925	3, 554	364	3, 190	1, 025	309	716
South Rocky Mountain	5, 141	43	5, 098	2, 778	34	2, 744	1, 686	3	1, 683
Total	396, 239	126, 723	269, 516	126, 265	35, 713	90, 552	105, 262	43, 381	61, 881

Region	Fair to satisfactory restocking areas			Poor to nonrestocking areas		
	Total	Farm woodland	Industrial	Total	Farm woodland	Industrial
	Thousand acres	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
New England	5, 851	1, 572	4, 279	2, 325	703	1, 622
Middle Atlantic	5, 072	1, 724	3, 348	2, 961	656	2, 305
Lake	24, 683	5, 399	19, 284	12, 133	2, 482	9, 651
Central	12, 078	5, 193	6, 885	5, 110	2, 375	2, 735
South	36, 802	12, 084	24, 718	43, 229	12, 264	30, 965
Pacific Coast	4, 324	1, 119	3, 205	6, 708	1, 312	5, 396
North Rocky Mountains	1, 540	407	1, 133	1, 219	333	886
South Rocky Mountains	16	5	11	661	1	660
Total	90, 366	27, 503	62, 863	74, 346	20, 126	54, 220

[1] From table 3 of section of this report entitled "Forest Land the Basic Resource".

In the section of this report entitled, "The Agricultural Land Available for Forestry," the Bureau of Agricultural Economics reports that in eastern forest regions there are now 50 million acres of nonforested farm land either abandoned or no longer required for agricultural use.

It also estimates that 30 million acres will be added to this area by 1950. In general, such of this land as is not selected for public forests will be available for private forestry. Planting will usually be necessary, but is entirely feasible where the area is merely part of a managed forest property or other enterprise yielding regular net income. This is specially true of farm enterprises.

PRODUCTION AND INVESTMENT CONDITIONS

Continuity of forest productivity depends on the economic factors common to all industry, viz, natural resources, labor (including management), and capital. Since natural resources that can be used to produce business profits have now in general been capitalized, the business enterpriser usually considers these in the category of capital.

TABLE 2.—*Amount of saw timber and cordwood on privately owned forest land in the United States*

Region	Saw timber[1]			Cordwood[2]		
	Total	Farm woodland	Industrial	Total	Farm woodland	Industrial
	Million feet board measure	*Million feet board measure*	*Million feet board measure*	*Thousand cords*	*Thousand cords*	*Thousand cords*
New England	55, 393	7, 972	47, 421	53, 450	19, 605	33, 845
Middle Atlantic	25, 831	12, 000	13, 831	116, 129	42, 904	73, 225
Lake	32, 733	10, 962	21, 771	115, 475	45, 505	69, 970
Central	34, 066	17, 453	16, 613	155, 242	61, 310	93, 932
South	195, 117	48, 267	146, 850	423, 613	171, 947	251, 666
Pacific Coast	593, 902	25, 206	568, 696	37, 011	9, 429	27, 582
North Rocky Mountain	41, 731	1, 508	40, 223	19, 050	6, 025	13, 025
South Rocky Mountain	9, 516	64	9, 452	6, 749	17	6, 732
Total	988, 289	123, 432	864, 857	926, 719	356, 742	569, 977

[1] From table 7 of section entitled "The Present and Potential Timber Resources" of this report.
[2] From table 9 of section entitled "The Present and Potential Timber Resources" of this report.

Using the term capital in this inclusive sense, it is readily possible to examine the situation of the privately owned forests from the standpoint of the presence or absence of the capital necessary to maintain a continuous output of forest products. Understanding of the situation is materially assisted by dividing the capital investment, thus interpreted, into its main elements and estimating what percentage of the whole is represented by each. The main elements of fixed capital investment are the soil, the forest improvements, and the forest growing stock or standing trees. The proportions of the capital investment which these elements represent differ to some extent in different regions of the United States; in any region, however, for a forest property maintained in good producing condition they will usually fall within the following limits:

Producing element:	*Percentage of capital investment*
Soil	0– 5
Forest improvements	5–15
Forest growing stock	80–95

The low percentage represented by the soil is in considerable degree due to neglect of the productivity of forest soils in the United States. In those European countries where intensive forestry is practiced forest soils are valued as high as $75 per acre, independent of the growing stock they carry. In such cases they constitute a higher percentage of capital investment than indicated above in the continuous yield forest.

The forest owner who extracts the raw material himself needs a moderate amount of additional capital for equipment and operating purposes. This is mobile capital, not necessarily tied up to any one property, and need not enter into the present discussion. Where a forest property is very intensively developed the proportion of investment in forest improvements, consisting mainly of transportation facilities but including some buildings, may be greater than 15 percent.

Where the forest growing stock has been removed, forest improvements usually become valueless. The same is more or less true of the forest soil. Attention from the standpoint of remaining capital values in privately owned forests should be directed to the classes of forest land shown in table 1 under the following headings:

Poor to nonrestocking.—Table 1 shows 74,346,000 acres in this class of privately owned forest land.[1] From this the growing stock has been entirely removed. The prospect of future income is so long deferred that soil value, also, has largely disappeared. It is doubtful that this area as a whole has 1 percent of the capital values necessary for continuous forest productivity.

Fair to satisfactory restocking.—Table 1 shows 90,366,000 acres in this class. Utilization of the young trees present by chance in so far in the future that here, also, forest capital is virtually lacking. The soil and trees together make up perhaps 5 percent of the capital necessary for reasonably continuous productivity. Capital investment alone will not immediately restore them, since the time requirement is inescapable.

Cordwood areas.—Table 1 shows 105,262,000 acres in this class. Privately owned cordwood areas include chiefly areas that have been depleted of saw-timber sized trees. They bear considerable stands of young trees which, if protected and developed, will grow into valuable timber. It is improbable, however, that their present capital value exceeds 20 percent of what it would be if they were built up to fully stocked producing forests.

Saw-timber areas.—Table 1 shows 126,265,000 acres of saw timber in private ownership. Even in this class more than one half of the privately owned area is occupied by second-growth stands that have suffered seriously from fire, insects, disease, and general lack of care. In regions of low precipitation, on extensive saw-timber areas the rate of tree growth is too slow for profitable management unless other resources are present. If private enterprise is to continue to function in the field of forest ownership, organized management of the remaining privately owned saw-timber area is immediately essential. If depletion of the forest capital (chiefly growing stock) in these forests is at once positively discontinued the problem of restoring the growing stock and productivity of associated depleted areas will be vastly simplified. Very little outside capital will then need to be brought in.

Since current or at least little-deferred income is a necessity in virtually all private business, timber that can profitably be cut in regular annual or periodic allotments is indispensable to private forest enterprise. On by far the greater portion of our forest area saw-timber stands must serve as a nucleus to every forest property expected to yield continuous annual income. The exceptions occur where pulpwood and other products which can be taken from small timber have a high value. The income possibilities of well-stocked saw-timber stands, such as exist plentifully on the Pacific coast and in portions of the north Rocky Mountain region and the South, are ample to permit including in private forest properties made up principally of such stands considerable portions of cordwood, restocking, and even nonrestocking forest area.

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[1] This total does not include the abandoned nonforested farm land mentioned in a preceding paragraph as potential forest land.

Possibly as much as 275 million acres, of which 125 million is in farm woodlands, is still adapted to carrying on private forest business operations on a sound and permanent basis. Should the opportunities in the field of private forestry prove widely attractive as the fundamental principles of forest management become better understood, it is possible that private enterprise will extend further into areas where the growing stock must be reestablished.

The section of this report entitled, "Present and Potential Timber Resources," subsection "Timber Growth" gives (in table 17) the results of a Forest Service investigation of growth of the forests of the United States as a whole, the most careful that could be made with the time and resources available. This shows a current annual growth, on both public and private forests, of 8,912 million cubic feet feet of usable material, including the equivalent of 11,731 million board feet of material of saw-timber size. It is safe to say that present growth on private forests does not exceed one fourth of what it might be even under crude forestry.

EFFECT OF LIQUIDATION POLICY ON THE FOREST RESOURCE

The foregoing brief summary of conditions on the private forest lands of the United States shows the effects to date of the application of the policy of "laissez faire" to the American forest resource. According to prevailing economic theory, if each private enterpriser pursues his own best interests the result of the aggregate of these efforts will be for the public welfare. The history of forest exploitation in the United States to date creates doubt as to whether this theory has justified itself as applied to the handling of natural resources. There is doubt as to whether this economic procedure has even operated to the advantage of the average private forest owner. Each time a forest region has been cut out to the point that lumber must be imported the freight charges per thousand feet of imported lumber have been far greater than what it cost to produce a thousand feet of stumpage in the region, if a sufficient growing stock had been reserved from the virgin forest. The regional result, then, has always been higher lumber prices plus a loss of local industry. For the great majority of individual owners the result has been termination of the enterprise without conversion of any considerable portion of the forest resource value to permanent forms of private wealth. The capital has been consumed currently instead of continuing to support industry and provide human sustenance. As in most other industries, it has been found impossible to make money while wasting capital assets on a huge scale.

PRESENT EXTENT OF SUSTAINED-YIELD PRACTICE ON PRIVATE FOREST LANDS

The formation of constructive forest policies for the future requires information as to how the remaining forest stands are being handled. Liquidation can be discontinued only through giving forest lands such care as will enable them to produce growth approximately equal in volume and value to the annual cut.

CONDITIONS IN COMMERCIAL FORESTS

During the year 1930 the Society of American Foresters, assisted by the Forest Service and by State foresters and others, made a Nation-wide investigation of the present management of private forest-land holdings more than 1,000 acres in extent. The investigation naturally centered on saw-timber and cordwood areas where cutting operations are still possible. There are perhaps 125 million acres of these areas, the size of the individual area averaging 1,000 acres or more. The results of this survey are shown in the following tabulation. All totals must be considered separately, because they overlap.

1.	Companies or individuals making conscious effort to grow timber commercially	288
	Acres under industrial forestry management	20, 951, 635
2.	Companies giving their lands good care without timber-growing purpose, whose chance to inaugurate forestry practice is still good	42
	Acres represented by these 42 companies	2, 243, 500
3.	Companies using careful cutting methods designed to promote natural regeneration	178
	Acres represented by these 178 companies	10, 568, 076
4.	Companies attempting to put their holdings on sustained-yield basis	40
	Acres represented by these 40 companies	3, 496, 631
5.	Companies providing effective fire control independently of public cooperation, in addition to other forestry activities	253
	Acres represented by these 253 companies	16, 884, 897
6.	Companies practicing close utilization in the woods	75
	Acres represented by these 75 companies	5, 896, 736
7.	Companies making growth studies	8
8.	Companies employing foresters in timber-production activities	79
	Foresters so employed	146
9.	Companies using consulting foresters	77
10.	Companies using regional association foresters' services	7
	(There is a general tendency to use Federal and State advice, and a few companies cooperate with forest schools.)	
11.	Companies planting beyond apparently experimental scale	76
	Acres represented (approximately)	100, 000
12.	Companies producing nursery stock for planting	14
	Trees produced annually by these 14 companies	30, 000, 000
13.	Companies spending money to control insects or diseases	60
14.	Companies using improved practices in turpentine operations (estimated)	48
	Acres represented (estimated)	1, 500, 000

During the present year data of similar nature have been procured by the Forest Service. No very material change has been noted in the extent of private forestry effort; in some regions, however, a tendency to abandon forestry practices is indicated. This tendency is rather more marked in the West than in the East. It was found impossible to segregate private owners' efforts in the field of forest fire protection from the efforts of public agencies cooperating with them. (Cooperative fire protection is discussed in other sections of this report.) Data as to measures to prolong productivity, and as to organized sustained-yield practice, are given in the following tabulation (as of 1931):

Region	Measures to prolong productivity	Organized sustained-yield management
	Acres	*Acres*
Pacific coast	1,224,050	209,400
Rocky Mountain	890,334	
South	2,755,000	1,354,000
Central States	1,560,000	92,600
Lake States	100,000	
New England and Middle Atlantic States	9,080,300	648,592
Total	15,609,684	2,304,592

Both tabulations show that forestry effort other than fire protection has been extended to less than 21 million acres. This is about 7 percent of the private forest area outside of farm woodlands. Sustained-yield management has been applied to slightly more than 2,300,000 acres, which is less than 1 percent of the privately owned forest area. These percentages would be larger if they were computed on the basis of the area which still bears sufficient growing stock for private operation.

Apparently private forest owners have not yet given adequate consideration to the advanced stage of liquidation of the private forests and to the savings realizable through conserving productive capital values. Further details in regard to the present status of private forestry in each forest region will be given later in this section.

CONDITIONS IN FARM WOODLANDS

Detailed information is lacking on the condition of farm woodlands. Numerous reports from observers show conclusively that as a rule the woodlands are producing to only a small fraction of their capacity. In nearly all regions fires continue to limit productivity; in some, the chief source of injury is unrestricted grazing. In all regions the woodlands suffer from cutting of trees that have not yet grown to a size to produce high-value material.

Notwithstanding these defects in management, farm woodlands are producing a large annual volume of forest products and are among the principal sources of farm income. The following data from the United States census of 1930 (*1*)[2] show the character and value of forest products cut from farm woodlands in 1929. (The quantities and values refer to products cut and ready for use or for marketing as raw material.)

Product	Number of farms reporting	Quantity cut
Saw logs and veneer logs	178,539	[a] 5,042,926
Firewood	2,431,921	[b] 34,110,529
Pulpwood	43,824	[b] 1,485,759
Fence posts	566. 233	[c] 98,664,249
Railroad ties	65,745	[c] 15,338,786
Poles and piling	21,802	[c] 3,298,415
Total value forest products from farms		$242,042,245

[a] Thousand board feet. [b] Cords. [c] Pieces.

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[2] For list of list literature and authorities cited see page at the end of this section.

In general, the annual cut of material from farm woodlands represents a sustained yield. In some regions, however, it is in considerable part made up of virgin or second-growth timber not being replaced in full measure by growth. Farm woodlands should be developed to sustain a larger output and larger local manufacturing industries. It is obvious from the above statistics that the proportion of high-grade material cut is lower than it should be. Diversion of considerable productive effort from other crops to forest crops would aid in relieving agricultural crop surpluses. The regional conditions will be discussed later.

ADVERSE CONDITIONS AND PRACTICES ACCOMPANYING THE LIQUIDATION OF PRIVATE FOREST LAND INVESTMENTS

UNWISE LOCATION OF MANUFACTURING PLANTS AND CONSTRUCTION OF EXCESS PLANTS

Economical utilization of forest products demands carefully considered location of the major manufacturing plants at points where forest raw materials can be concentrated at low cost and the manufactured product economically distributed to market. It also demands that no more plants be built than are necessary to utilize the production. Sometimes, of course, there are reasons for building temporary plants and for building plants disproportionate to the continuous productivity of the forest. Gross overbuilding and consequent wastage of capital both in building and in subsequent competitive marketing have occurred in every forest region. Such losses have been accentuated in late years, owing to the ease with which modern industrial methods produce large output.

Accompanying these losses, the taxation problem usually becomes acute. Stimulated development entails the presence of more people and hence necessitates more schools, roads, and public services than will be needed permanently. This requires the levy of taxes beyond the amounts necessary under sound development. Moreover, as liquidation progresses the tax base becomes narrower, so that near the end of the liquidating period it is difficult to raise the revenues needed for the population which remains until plant operations cease.

Poor location of plants, lack of integration, and excessive number of plants requiring the same kind of raw material in one locality contribute to losses discussed in the following.

FAILURE TO COORDINATE DIFFERENT WOOD USES

Wood uses in the United States cover a wide range of products. Table 13 of the section of this report entitled "The Present and Potential Timber Resource" shows 20 major items of wood use requiring the cutting of 14,495,308,000 cubic feet of timber from our forests annually. Of this quantity slightly more than one half is cut for lumber purposes. As shown in the same table, additional uses requiring saw timber sized trees bring the cut of saw timber to about 70 percent of the average cut of the years 1925 to 1929.

Of the cordwood material used annually, 35 million cords are taken from trees under saw-timber size. There is no doubt that this cordwood could be supplied entirely from the remnants of saw-timber trees and from thinning operations. Unfortunately, because of the somewhat localized use of fuel wood and the haphazard location of manufacturing plants which use such material, in many cases no market for material of this class exists within reach of the localities where the material is available. In many cases, however, coordination between saw timber and other uses is feasible but has not been effected, owing to indifference of forest owners, careless buying policies of manufacturers, and other causes. This has led and still is leading to the unnecessary sacrifice of young stands over large areas at the same time that prodigious waste is occurring in the utilization of saw-timber stands in the same localities. Millions of acres of young stands could be improved by thinning operations that would meet these cordwood requirements.

The outstanding example of woods waste resulting from lack of coordination of saw-timber with other operations is to be found in the Pacific Northwest. In an exhaustive study of logging waste in the Douglas fir region in 1926 and 1927 Hodgson (*2*) found that the waste averaged 42 cords per acre and totaled 6,448,000 cords annually. Virtually all this waste was of species suitable for one or another of the pulp processes. The volume of waste exceeded the entire quantity of pulpwood used in the United States. There is no immediate possibility of developing the pulp industry in that region to the point at which it could use all the waste. The waste could, however, be reduced by properly selecting trees for cutting, by adopting less destructive logging machinery, and by better balanced utilization. These measures are discussed later under the description of the Douglas fir region. Hodgson estimated that with a slight improvement in the economic conditions in the lumber industry at the time of his study, one third of the waste in the form of logs could be used for lumber.

OTHER FACTORS AFFECTING PRIVATE FORESTRY CONDITIONS AND POLICIES

DEMAND FOR FOREST PRODUCTS

The demand for forest products is treated fully in the section of this report entitled "Our National Timber Requirements." Here it suffices to point out that careful investigation of market requirements, while showing changes in the varieties of forest products marketed and shrinkage in the use of some forest products, indicates large continuing requirements. Landowners undertaking to manage forest land for continuous production are unquestionably entering a unique field of endeavor, in which the production of surpluses resulting from new growth is wholly improbable for at least a generation to come. Competition with timber properties that are being liquidated will apparently be the most serious limiting factor for the next few years.

Many communities in the forest regions of the eastern half of the United States are suffering from a lack of industrial balance resulting from decline in the forest resource. Where agriculture is the chief remaining resource, usually the local market for agricultural products has virtually disappeared and agricultural products must be marketed at a distance in direct competition with products from other agricultural areas. Restoration of forest productivity in these regions would gradually restore the local market and the direct exchange of farm and forest products, and would make the community largely self-supporting from the standpoint of the great essentials of food and shelter. Data from many countries show conclusively that wherever these conditions of local production exist the per capita use of forest products far exceeds the per capita use in regions where these products have to be brought in from a distance at greatly increased costs.

STABILIZATION OF OWNERSHIP AND BLOCKING UP OF AREAS FOR PERMANENT MANAGEMENT

Institution of a private forestry enterprise requires a property the parts of which are at least adjacent and are so situated as a whole and with relation to each other that economical transportation facilities either exist or can be established, that existing markets can be economically reached or new markets created, and that all other factors of management can be properly coordinated. It is evident that the 127 million acres of farm woodland are already blocked up and represent ownership stability of the same order as exists for farms. The division of this section dealing with the extent of private forestry shows that possibly as much as 21 million acres of private commercial forest lands have been placed under some type of improved care in addition to fire protection. It is known that other commercial forest areas have been consolidated for exploitation purposes in a manner that would meet the requirements of permanent management. Enormous areas in unstable ownership remain to be redistributed among various forms of public and private ownership. The sooner this is done, with adequate precautions against mistakes, the more quickly the process of deterioration on these areas can be arrested.

ECONOMIC SIZE FOR FOREST PROPERTIES

Farm-woodland properties vary in size from 5 acres or less to 1,000 acres or more. The farm woodland is in a separate category in that it forms part of a unit managed chiefly for the production of crops other than forest crops. Certain industries other than agriculture, of which mining is a prominent example, may be linked in a similar manner with forestry operations on a small or large scale. Recreational use of land, particularly by country clubs or hunting clubs, is sometimes joined with forest production. Even for areas devoted more exclusively to timber production no general rule as to operating size can be laid down, because production of all types of forest raw material can be carried on either on one-man units of a few hundred acres or on very much larger units. Very seldom, however, will any economic advantage accrue from the assemblage of operating units of more than 100,000 acres. From the administrative standpoint it is extremely advantageous that the typical forest property remain of small size, subject to the detailed attention of the owner or operator; but this places the industry at some disadvantage from the standpoint of employing technical advisors and carrying on necessary research activities. For this reason it has proved necessary that research, and to a certain degree technical advice, be provided at Federal and State expense in the case of forestry as in that of agriculture.

ORGANIZING FOREST PROPERTIES

As in the case of any other property to be operated over a long period of time, carefully planned development and operation will add largely to the value of forest property and will increase the returns. Definite plans should therefore be made covering development and the main phases of operation for a period of five or ten years. These plans must consider engineering phases together with production and economic problems. Once the owner has decided to place the property under permanent management, it is natural that he will exercise more care in developing it. This does not always mean spending more money on transportation and like facilities than is spent on the exploitation forest; transportation facilities costing untold millions of dollars have had to be abandoned and written off the books as a result of the liquidation policy of cutting forests. It has been calculated that in a normal year as much as 1,400 miles of logging railroad, equivalent to half a transcontinental line, has been built in the Douglas fir region alone. Under an exploitation policy all this is abandoned and the investment written off in a few years. Under a continuous-production policy very few temporary facilities are built. Construction is not extended so rapidly, but the structures are permanent.

Since methods of handling forest stands for continuous production vary for different types, they will be discussed separately for each region, later in this section. The subject is raised here only to point out that all operations in the timber should be planned systematically for a reasonable period of years. The plans should provide both for obtaining current income from cuttings and for conserving permanent productivity.

Obviously, when such planning is to be performed, the measures prescribed must be attached to specific portions of the property. This necessitates mapping, and laying out permanent subdivisions with roads or topographic features as boundaries, so that extraction of forest raw materials can be carried on in the most economical manner when and where prescribed.

The planning just discussed will include budgeting the annual financial operations. The following headings suggest the main items usually included in such a budget:

A. Operating account:
  Expense:
    1. Administration
    2. Taxation
    3. Protection
    4. Engineering and construction maintenance
    5. Insurance
    6. Capital charges (annual)
      (*a*) Interest
      (*b*) Depreciation
    7. Silvicultural costs
    8. Other costs
  Income:
    1. From sale saw logs or timber
    2. From sale pulpwood
    3. From sale posts and poles, etc.
    4. From grazing
    5. From recreation, etc.

B. Capital account:
  1. Road construction
  2. Building construction
  3. Other improvements
  4. Purchase and sale of property
  5. Etc.

Special attention is called to the fact that all items of expense except the silvicultural occur under any intelligent policy of responsible and permanent land management. Silvicultural expense is often a minor item and may not be present at all. As the operation becomes established it will usually be found profitable to set up at least a small budget item under that head. At this point it is desired to lay all possible emphasis on the fact that the outstanding financial and physical function of forestry is saving, not cost. Forestry saves productivity, saves forest land investments, saves forest improvement investments, prevents depletion, and saves all sorts of community investments dependent on continued productivity of the forest resource.

POTENTIAL PRODUCTIVITY

As in the case of agricultural production, rapid rates of growth and high yields are important favorable factors to be considered in carrying on forestry as a business. During the past few years studies of yield have been completed for many important American forest tree species, especially among the conifers. Species of rapid growth and high value are to be found in every important forest region.

Table 3, adapted from a table compiled by I. T. Haig (*3*), shows rates of growth and yield in terms of cubic feet and board feet for many different conifers of the United States. It should be noted that the average production over entire forest properties cannot be expected to amount to more than 60 to 75 percent of the growth rates shown in the table, which are those of fully stocked stands. Such species as redwood, sugar pine, and Douglas fir on the Pacific coast, white pines in Idaho and the Northeastern States, and loblolly, shortleaf, and slash pines in the Southern States, equal or exceed the growth rates of coniferous trees to be found anywhere else in the world. The same is true of our hardwood species as compared with hardwoods elsewhere in the north temperate zone.

The mere fact that a given species in an even-aged stand may grow rapidly from the time of origin of the stand to the time of harvest 60 or more years hence does not necessarily mean that the business of growing such stands from origin to maturity will yield a profit. Even if proved profitable in the long run it may not promote a business set-up that is within the field of private capital unless the forest property includes stands of many ages. For these reasons this discussion must be concerned chiefly with the current growth rates of trees approaching maturity in selection forests, or forests where a wide range of age classes are present in groups. Growth figures in connection with consideration of growing-stock conditions in various forest types will be presented under regional discussions.

TABLE 3.—*Rates of growth of 12 commercially important conifers*

Region	Species	Average site, or site index	Age on which site index was taken	Maximum average annual growth per acre		Age at which mean annual increment culminates		Yield per acre at 60 years		Reference
						Cubic volume	Bd. feet volume			
			Years	*Cubic feet*	*Board feet*	*Years*	*Years*	*Cubic feet*	*Board feet*	
South	Loblolly pine	90	50	131	750	35	50	6, 700	43, 000	(1)
Do	Longleaf pine	80	50	101	573	50	75	5, 950	33, 500	(1)
Do	Shortleaf pine	70	50	110	558	40	60	6, 000	33, 500	(1)
Do	Slash pine	80	50	143	567	15	45	5, 750	32, 000	(1)
New England	White pine	I		136	828	45	60	7, 980	49, 700	(2)
Do	Red spruce	50	50	80	310	65	80	4, 780	13, 300	(3)
Lake States	Northern white pine	60	50	121	739	70	90	7, 200	36, 500	(4)
Do	Jack pine	Medium.		79	214	35	70	3, 750	11, 500	(5)
North Rocky Mountain	Ponderosa pine	Medium.		59	298	40	110	3, 300	14, 610	(6)
Do	Western white pine	60	50	118	760	100	120	5, 880	23, 250	(7)
Pacific Northwest	Douglas fir	160	100	170	1, 190	70	80	10, 200	66, 200	(8)
California	do	100	50	180	962	50	70	10, 500	56, 900	(9)
Do	White fir	60	50	128	750	70	90	7, 400	36, 500	(10)
Do	Ponderosa pine	III		66	350	120	130			(11)
Do	Redwood	II		310	1, 930	45	55	17, 100	115, 000	(12)

(1) U.S. Department of Agriculture Miscellaneous Publication 50; (2) Harvard Forest Bulletin 7; (3) U.S. Department of Agriculture technical bulletin 142; (4) University of Wisconsin Research Bulletin 98; (5) University of Wisconsin Research Bulletin 90; (6) University of Idaho, Forest Experiment Station Bulletin 1; (7) mimeograph report, U.S. Forest Service; (8) U.S. Department of Agriculture technical Bulletin 201; (9) University of California, College of Agriculture, Bulletin 491; (10) University of California, College of Agriculture, Bulletin 407; (11) Journal Agricultural Research 31, 1121–1135; (12) University of California, College of Agriculture Bulletin 361.

ADJUSTING GROWING STOCK TO PRODUCE MAXIMUM RETURNS

It has already been pointed out that on forest properties expected to pay their way under private forest management the growing stock usually represents 80 to 95 percent of the total investment. Two factors dictate that a growing stock of varying ages be carried at all times: first, valuable merchantable material is produced only by many years' growth of a tree or stand; second, annual income can be obtained only by maintaining a succession of size classes, so that as the larger trees are cut others grow up to take their place.

CUTTING AND MANAGEMENT SYSTEMS

The many silvicultural systems recognized (*4*) form two major systems of handling cuttings in saw-timber forests as regards treatment of trees of different ages or sizes. The clear-cutting system (fig. 1) removes the complete stand at once over considerable areas, with the result that if another stand follows it grows up even aged. The chief defects of this system are that natural regeneration often does not follow and that a large portion of the trees cut are removed at a loss when they might have been left to add valuable growth and reach maturity at an early date. The American forest regions in which this system has generally been followed have the most seriously depleted forests.

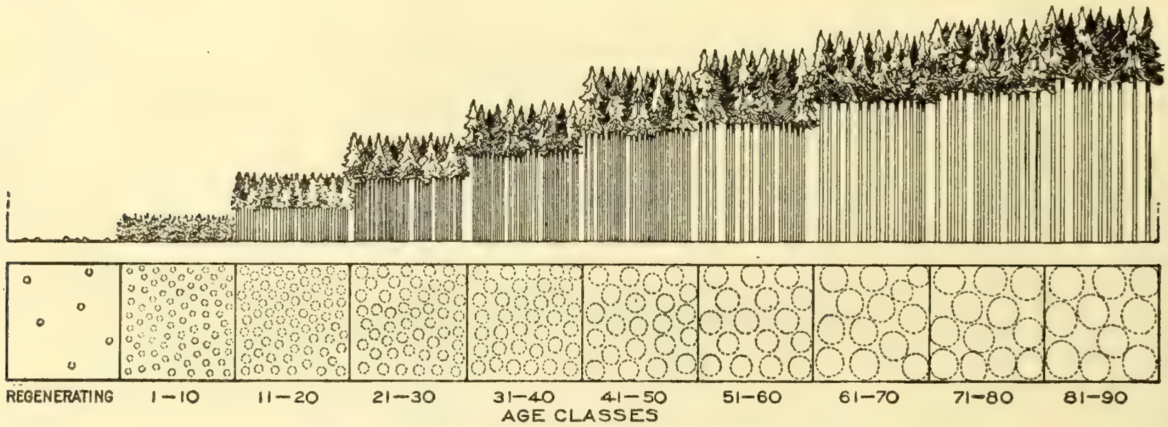

FIGURE 1.—Forest with series of even-aged stands.

The selection or partial-cutting system (fig. 2) removes trees of merchantable size either individually or in groups with the minimum interference to the growing trees left. Young stock develops on the same ground occupied by the larger trees or in small openings, with little or no assistance or cost. The proper arrangement of cuttings among the larger trees aims to maintain on every division of the forest a growing stock of trees from 6 to 40 inches or more in diameter which are capable of earning currently through their continued growth the income necessary to pay all the operating costs and a net income besides. This income is not taken annually on every acre; the cut is rotated over the area once every 5 to 20 years. At each return to a given area 5 to 20 years' growth is harvested. The range of diameter classes in the stand varies with the species.

In considering the present condition of the growing stock in various forest types, its progressive modification in the course of cuttings to obtain current income, and the reservation of trees of proper sizes and characteristics to provide the best possible continued growth and earnings, discussion is based on the assumption that this system of selection or partial cuttings will be followed in virtually all private forestry. It is recognized, however, that certain species such as Douglas fir, most of the pines, yellow poplar, white ash, and many oaks will not regenerate except in full or nearly full light. Therefore, the selection system as here contemplated includes "group selection" meaning that when regeneration of light-demanding species becomes necessary openings will be made in the stand, varying according to the species, the locality, the site, and the stand conditions from about one sixty-fourth of an acre to 5 acres in extent. In a few regions such as the Douglas fir region where regeneration comes easily and early growth is rapid, openings may occasionally be as large as 25 acres or in exceptional cases even larger. Data on growing-stock conditions in representative types and regions are presented with the understanding that the average acre given represents conditions in stands now on a selective basis or, where the stands are even aged, that the suggestions for treatment contemplate conversion to that basis. The data and suggested treatment can be most readily visualized if thought of as applying to a forest area division of 25 to 200 acres, usually termed "compartment." The treatment recommended contemplates that every such compartment in a forest property shall at all times be stocked to the best advantage with trees of a certain diameter range, for most species from 6 to 40 inches or more, capable of laying on annual growth of high value.

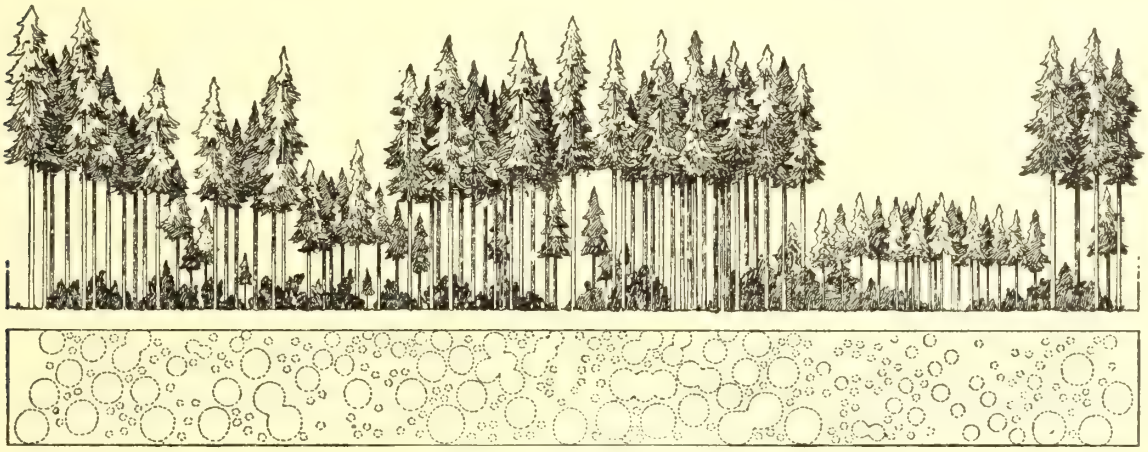

FIGURE 2.—Selection forest.

The selection system has certain subsidiary advantages. It is safer from fire. Intensive research in various regions, notably the Northeastern, the North Rocky Mountain, and the Pacific coast, have proved that forest litter is inflammable a much larger portion of the time in the open than in the shade. In effect, in the forest the fire season is shorter. Also, larger trees are not so easily damaged by fire and can maintain a considerable rate of growth for the stand even if some smaller trees are occasionally killed by fire. Wind velocities are diminished by the larger trees, and fire is more easily controlled owing to this factor and to the fact that the low crowns of the young trees do not occur over large continuous areas.

Another advantage is that it is not necessary to cut trees of all sizes simultaneously; cuttings can be regulated according to market demands. The forest well organized on this basis is like a well-ordered warehouse in which the owner can take any goods he desires off the shelves and thus meet varying demands for different classes of materials. At one time saw timber may be in heavy demand; at another, pulpwood from thinning the groups of smaller trees.

Since American examples of intensive forestry practice with adequate record keeping over long periods of time are lacking, the desirable growing-stock conditions in a forest developed according to the principles discussed above are best shown by citing a European example. The communal forest of Couvet in the Canton of Neuchatel, Switzerland, is appropriate owing to careful direction of its management for many years by the eminent Swiss forester Dr. H. C. Biolley and owing also to the careful, detailed records (*5*). This forest, under continuous-yield management for many years, has been subjected since 1890 to a careful procedure of building up the growing stock in order to improve the volume and quality of production. To a remarkable degree, this has been accomplished without any impairment of the periodic cut at any time and with a material increase in the later periods.

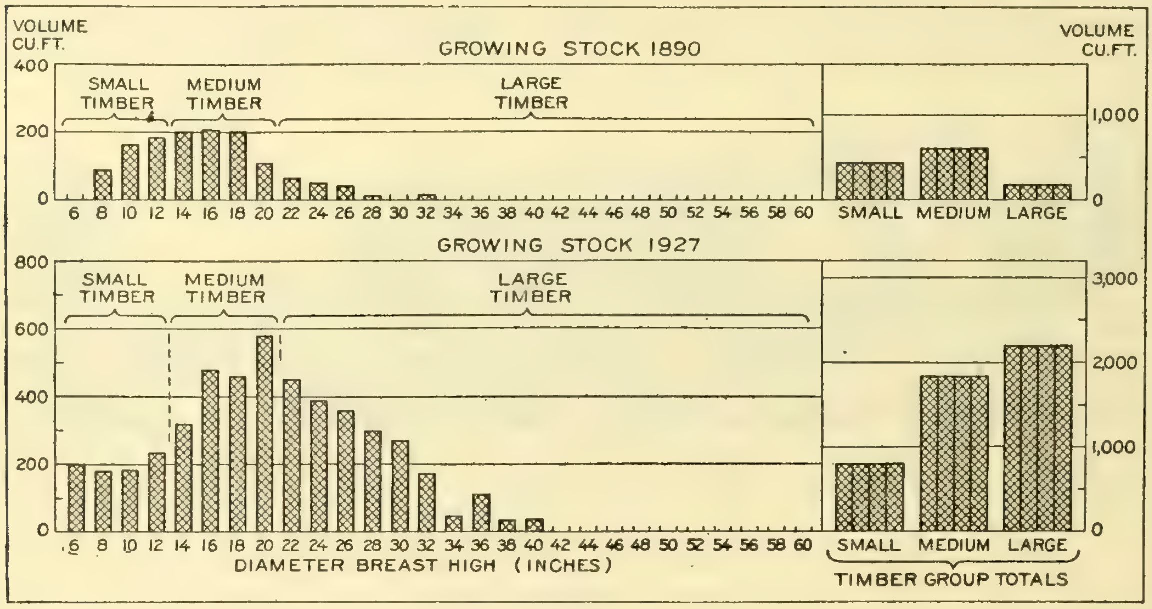

Figure 3.—Distribution of cubic volume by diameter classes on average acre, communal forest of Couvet, Switzerland.

Figure 3 shows graphically the condition of the stand in 1890 and its condition in 1927. The figures have been converted as accurately as possible from metrical units to English measurements and are in terms of the average acre in one division of the forest. The volume of the growing stock has been built up from about 1,246 cubic feet per acre to about 4,840 cubic feet per acre.

The annual cut per acre has been increased from 74 cubic feet to 128 cubic feet, and the average size of the trees cut more than doubled. The latter point is of extreme importance in increasing financial returns, owing to the higher unit value of large trees. The annual net returns did in fact increase during this period from $8.41 to $25.03 per acre. In America the closest resemblance to this Swiss example in species and growth conditions is to be found in the forests of the north Pacific coast, but a study of these diagrams will be instructive for forest managers in other regions as well. Some of our hardwood types can not be expected to bear any close resemblance to this example.

Within the past decade the application of production engineering technic to the study of logging and sawmilling practice has revealed that cutting operations in this country have been removing vast numbers of small trees, not alone to the severe impairment of the future productivity of the forest but also at a very heavy present loss. Table 4 shows results of such studies in six widely separated localities and in stands of different species. These studies were carried on entirely independently by different investigators, but all the results agree in principle. For each species cut for the general lumber industry there is a diameter limit below which cutting results in definite loss. Since stumpage is not charged as a cost in these studies, the data in the table mean that the trees below this diameter limit not only yielded no stumpage return from cutting but also caused a definite cash operating loss. All tree diameters above the upper heavy line drawn horizontally through the table are in this losing category. It is a mistake to cut trees even to this limit, for the reason that most of the sound growing trees capable of yielding only low returns from cutting now are more valuable for holding. It can be recommended then that as a general rule only trees of the sizes shown below the lower heavy line should be cut. The exceptions to this rule are trees of all sizes that are not of form and condition to grow further in value but on which something can be realized if they are cut at once. The trees of the sizes shown above the lower heavy line constitute the forest capital left after each cutting, which is responsible for the future earnings of the forest.

APPLICATION OF THE SELECTIVE CUTTING SYSTEM IN THE UNITED STATES

For more than a century European foresters have carried on cuttings on the principle of so selecting the trees to be cut that the residual stand will consist of trees capable of further growth in volume and value. In other words, they have managed cuttings in a manner to improve the stands. American foresters have advised a similar practice, but this procedure has seldom been followed on private lands in the United States.

TABLE 4.—*Net stumpage realization values per M feet board measure and per tree by diameter class, various species and regions, as determined by logging and milling studies* [1]

Diameter classes	Douglas fir [2] (Washington)		Sugar pine [3] (California)		Ponderosa pine [4] (Montana)		Shortleaf pine [5] (Arkansas)		Loblolly pine [6] (Virginia)		Red oak [7] (North Carolina)		Northern hardwoods [8] (Lake States)	
	Per M feet board measure	Per tree	Per M feet board measure	Per tree	Per M feet board measure	Per tree	Per M feet board measure	Per tree	Per M feet board measure	Per tree	Per M feet board measure	Per tree	Per M feet board measure	Per tree
8 inches							−$4.67	−$0.21	−$12.35	−$0.41				
10 inches							−.05	−.01	−5.60	−.33			−$2.93	−$0.18
12 inches					−$4.28	−$0.38	3.08	.35	.49	.05			1.00	.09
14 inches	−$18.45	−$1.84	−$21.15	−$2.12	−.46	−.06	5.59	1.06	5.23	.85	$4.75	$0.33	5.22	.68
16 inches	−13.94	−2.23	−13.51	−2.30	3.44	.65	7.59	2.08	8.31	1.99	7.60	.87	9.21	1.93
18 inches	−9.62	−2.31	−9.36	−2.15	6.19	1.55	9.36	3.64	10.80	3.42	10.10	1.72	12.87	3.47
20 inches	−5.48	−1.92	−6.52	−2.28	9.29	3.48	10.92	5.07	13.07	5.29	12.25	2.82	16.03	5.45
22 inches	−3.26	−1.66			12.19	6.03	12.26	8.43	15.19	8.05	14.24	4.27	18.95	7.96
24 inches	−1.17	−.76			14.08	9.22	13.54	10.38	16.83	11.51	16.04	6.10	21.59	11.23
26 inches	−.06	−.05			14.65	12.31	14.64	15.22	18.19	13.95	17.47	8.21		
28 inches	1.00	.93			14.55	15.28	15.69	20.21	19.05	16.25	19.01	10.84		
30 inches	2.19	2.36	3.33	4.66	14.38	19.12	16.73	25.70			20.55	14.28		
32 inches	5.06	6.48			14.37	24.43					21.92	18.52		
34 inches	5.55	8.16			14.55	29.83					23.20	23.66		
36 inches	5.67	11.06			15.56	36.88					24.33	29.44		
38 inches	6.09	14.25			18.31	48.16					25.27	36.05		
40 inches	6.10	17.45	10.84	33.60										
50 inches	7.15	31.89	17.87	99.89										
60 inches	8.85	60.18	24.57	226.04										
70 inches	8.84	83.18	27.44	335.86										
80 inches	9.38	113.97												

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[1] By net realization value as shown in this table is meant the sum accruing to the timber operator, as stumpage, after deducting all operating costs from the market prices actually obtained for the product when sold. The percentages of each lumber grade produced from trees of each diameter class were determined in all studies. The current prices of each grade were applied to these percentages to determine the average price per M feet board measure by diameter classes. Logging and milling operating costs per M feet board measure for each diameter class were deducted from the lumber value to determine the net remaining. This is the realization value per M feet board measure. Realization value, per tree, for each diameter class is obtained by multiplying the value per M feet board measure by the number of M feet board measure, per tree in each diameter class. Further details of the methods of conducting these studies are to be found in any of the reports cited.

[2] Data from unpublished report on logging and milling studies in the Douglas fir region—Pacific Northwest Forest Experiment Station.

[3] See citation no. 6.

[4] See citation no. 7.

[5] See citation no. 8.

[6] See citation no. 9.

[7] See citation no. 10.

[8] See citation no. 11.

The movement of the value of the individual tree as the tree grows from one diameter class to another is due not only to the fact that the larger tree contains more wood but to the fact that the larger tree is more cheaply logged and milled, proportionately, and that its lumber is of higher average value. Under normal conditions the practice of holding sound, thrifty trees until they reach the stumpage realization values of from $5 to $10 per M board feet (shown below the lower heavy line in table 4) is likely to result in very satisfactory earnings. The probability of its doing so depends on the length of time it takes trees of a given diameter class to grow to the next higher diameter class.

Table 5 shows how gross compound interest earnings vary according to the number of years required to grow from one diameter class to the next higher, when realization values change as in the loblolly pine stands on which data in table 4 are based. The top line of compound interest earnings opposite 4 years shows the gross interest gained when any diameter class changes to the next higher, if the change takes place in four years. The rates earned if the change takes six years are shown on the second line, etc. The faster growing of the 12- to 18-inch loblolly pine trees grow 2 inches in 4 years in some localities and do so commonly in 6 to 8 years. The heavy line drawn downward through the table separates the diameters and growth rates which earn 6 percent or more gross compound interest from those that earn less than 6 percent. Taxes and other costs usually amount to from 1½ to 2½ percent of capital value, so that trees that earn 6 percent gross earn about 4 percent net. In general it is believed good business to hold trees as long as they earn 4 percent net. For loblolly and shortleaf pines this indicates a guiding diameter limit of about 17 or 18 inches. Well-formed, sound, rapid-growing trees above that limit continue to earn 4 percent or more net, while smaller trees of poor growth earn less than 4 percent net. Thus finance as well as silviculture indicates a flexible diameter limit to guide cutting. In regions of exceptionally rapid growth the lower limit of earnings that justify holding a tree may perhaps be set higher than 4 percent

TABLE 5.—*Gross earnings on timber investment due to tree growth*

Time required by tree to to grow from one diameter class into next higher	Diameter classes (inches)										
	8	10	12	14	16	18	20	22	24	26	28
	Average net realization value per tree in each diameter class (dollars)[1]										
	−0.41	−0.33	0.05	0.85	1.99	3.42	5.29	8.05	11.51	13.95	16.25
			Gross earnings when tree enters next higher diameter class (compound-interest percentage) [2]								
4 years	------	------	103.1	23.6	14.4	11.5	11.1	9.4	4.9	3.9	------
6 years	------	------	60.3	15.2	9.4	7.6	7.2	6.2	3.3	2.6	------
8 years	------	------	43.1	11.2	7.0	5.6	5.4	4.6	2.4	1.9	------
10 years	------	------	32.8	8.9	5.6	4.5	4.3	3.6	1.9	1.5	------
12 years	------	------	26.6	7.3	4.6	3.7	3.6	3.0	1.6	1.3	------
14 years	------	------	22.4	6.3	3.9	3.2	3.1	2.6	1.4	1.1	------
16 years	------	------	19.4	5.5	3.4	2.8	2.7	2.3	1.2	0.9	------
18 years	------	------	17.1	4.8	3.1	2.5	2.4	2.0	1.1	0.8	------
20 years	------	------	15.2	4.3	2.7	2.2	2.1	1.8	1.0	0.7	------

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[1] Values are those given for loblolly pine in Virginia in table IV. They are based on a logging and milling study made in 1929 (*9*).

[2] Percentages shown in the 12-inch diameter column represent earnings due to growth from the 12-inch into the 14-inch diameter class. The percentages of course apply only to the trees that remain alive through the period required in each case to make the 2-inch increase in diameter. No deduction has been made for the expense of holding the trees during the respective periods. This item usually amounts to 1½ to 2½ percent of the capital value.

The sum of the values tied up in diameter classes at the left of and above the heavy line constitutes the investment in growing stock in terms of immediate realization value. All smaller tree sizes that show no immediate realization value can be valued, if at all, only by discounting the value they will have when merchantable.

The rate of earnings made by the trees in the residual stand is the principal guide in choosing trees for cutting. Where the forest is very deficient in growing stock it may be desirable to raise the guiding limit. If, on the other hand, there is a surplus-of growing stock, more small trees should be taken, to increase the growth and earnings of those left. At all times, trees of less than the chosen size but defective or indicated for removal to thin the stand should be taken if they can be marketed without loss. Selecting high-value saw timber and other valuable trees to produce the main income, and surplus, and ill-formed trees for cordwood uses, not only provides the forest owner with the maximum income from his property but also provides cordwood-using industries with cheaper products than can be produced independently of saw timber.

Conditions in typical stands in most of our important forest types are shown in 15 figures and 12 tables in conjunction with descriptive text distributed throughout the following regional discussions. In most of these figures heavy curved lines indicate the suggested limits of the permanent growing stock. It should be emphasized that while the suggested growing stock will without doubt provide for satisfactory rates of production in practically every case, these conclusions are only tentative. Careful investigation is needed to fix growing stock limits in any given case, and even then adjustments will constantly be necessary. These adjustments should be based on the fundamental principle of retaining a growing-stock investment sufficient to make the earnings of a forest property approximate the maximum possibilities. In the final analysis maintaining a sufficient growing stock is a matter of thrift—saving sufficient of the forest capital to provide for a high rate of continued forest productivity.

The reasons for the distribution of cubic volume among the different diameter classes and timber groups are as follows: The small timber (8- to 12-inch diameter classes) should be maintained only in sufficient numbers and volume to replace losses by mortality in all groups and recruit the medium timber as trees are removed from it by cutting or growth into the large timber group. The medium timber group (14- to 20-inch diameter classes), since it is generally the source of the highest investment earnings, should usually be maintained at a maximum of volume. Exceptions to this occur in the Pacific coast region where the production of large timber should be a constant aim. In other regions the proportion of the stand composed by the large timber group (22 inches diameter and over) may be expected to fall off rather rapidly with increase in size of the trees, because the trees have passed the point of large investment earnings. In these regions only a few exceptionally well-formed and vigorous trees should be held until they grow into the large-diameter classes.

REGIONAL CONDITIONS AND MANAGEMENT PRACTICES

PACIFIC COAST FORESTS

(Washington, Oregon, and California)

PRIVATELY OWNED TIMBER ACREAGES

Large-scale lumber production originated comparatively recently in the Pacific coast region. Cutting and other causes has already, however, removed the larger growing stock, suitable for continuous operation under a group or tree selective system, from one third of the privately owned area. Out of 33,037,000 acres privately owned, 6,708,000 acres are rated as nonrestocking and 4,324,000 acres as fairly well restocked with young growth. Farm woodlands include 5,099,000 acres; other areas in private ownership total 27,938,000 acres. The total regional privately owned stand is estimated at 594 billion board feet.

MANAGEMENT POLICIES

Until very recently, wherever the heavy stands of the Pacific coast region were operated, clear cutting was considered necessary, for mechanical and other reasons. (It was not considered necessary in the ponderosa pine stands.) Recent changes in logging machinery, including improvement of crawler tractors and development of associated log-tractor devices, make selective cuttings, either by single trees or by groups, entirely feasible. Selective cuttings are already freely practiced in some forest types, while in others only a beginning has been made. Most forest owners still hold to a policy of liquidating timber holdings. A few, realizing that present methods are undesirable, are considering or initiating changes in operating policy. Present management policies will be considered under three headings.

PROTECTION FROM FIRE

For most forest types in the Pacific coast region fire protection is recognized as prerequisite to sustained forest productivity. The standards of protection necessary under various conditions, and other aspects of the forest-fire problem, are discussed in detail in other sections of this report. Here it is sufficient to note that while some fire-protective effort is being made as a result of compulsory State patrol laws on virtually all the better-class timberlands, the burning rate has not been reduced to a low enough level to permit full productivity. Fire-protective efforts have made great progress and are unquestionably sufficient to permit a large volume of growth to take place, especially in the moist Douglas fir region.

MEASURES TO PROLONG PRODUCTIVITY

These include selective cuttings and intensive protection of young growth from logging damage. Nine Pacific coast concerns are practicing such measures on 1,224,050 acres. On considerable additional areas, without special intent on the part of the owners, conditions obtain that, as compared with the prevailing practices, will in some degree prolong the cut or productivity.

OPERATION ON A SUSTAINED-YIELD BASIS

Full utilization of productive values of the soil and full returns from investments in log-transportation systems, manufacturing plants, dependent communities, etc., are possible only under a complete sustained-yield policy. Such a policy has been initiated by four Pacific coast operators owning about 209,400 acres of land and appears to be permanently established on these holdings. A number of the concerns mentioned in the previous paragraph have adopted management policies that could easily be altered to provide for sustained yield. In addition to this the redwood region, which with associated types comprises 1,400,000 acres, was formerly considered to be almost entirely on a sustained-yield basis. The redwood and associated forests are estimated to be capable of producing a sustained annual yield of one billion board feet. During the depression period, unfortunately, forestry practices have been discontinued on many redwood areas and even fire protection is now in a very unsatisfactory status. In this region the values that are subject to preservation through effective forestry measures are so large that resumption of these practices may reasonably be expected. Since virtually all the timber is in large ownerships, generally strongly financed, it is to be hoped that the owners will eventually adopt the policy that promises the greatest profits in the long run.

PRODUCTION AND CONSUMPTION OF FOREST MATERIALS

The annual lumber cut of the Pacific coast region is about one third of the national cut. There is little prospect in the near future of increased markets for the grades of lumber which make up the bulk of the present shipments out of the region. Especially as regards shipments to eastern markets for domestic consumption, other regions offer very keen competition in the lower grades. The competing eastern and southern forests, although now low in productivity per acre, are so vast in extent that they will inevitably continue to produce at lower cost to the consumer much of the forest material of ordinary grades required in the eastern United States. On the other hand the forests of the Pacific coast provide certain products, such as large timbers, wide clear boards, and veneers, that are hard to procure in quantity from any other coniferous forest region of the world. There are good possibilities of world-wide market extension for these products. If such extension is to be attempted it seems obvious that forest-management methods should be adapted to the continuous production of these classes of materials. Disastrous competition between the Pacific coast and eastern regions is likely to continue if excessive production of low-grade lumber is persisted in. The continued supply of high-quality products from the Pacific coast, however, will assist in effective utilization of local materials in eastern regions, through maintaining the position of wood as an acceptable building and industrial material. High-quality trees contain a large proportion of low-grade material, and the production of such trees is accompanied by the production of many small trees which will yield low grades if cut into lumber. West coast consumption can be counted on to absorb much of the lower-grade lumber produced in the region. Railroad ties and other products not of the highest value will continue to find a market in world trade. Table 6 shows the production and consumption of lumber for each State and for the region in 1928 (*12*).

TABLE 6.—*Production and consumption of lumber in the Pacific Coast Region in 1928*

[In thousand feet board measure]

	Production [1]			Total [2] consumption
	Softwood	Hardwood	Total	
California and Nevada	1, 952, 458	201	1, 952, 659	3, 158, 011
Oregon	4, 361, 904	10, 020	4, 371, 924	1, 044, 709
Washington	7, 291, 924	13, 353	7, 305, 277	1, 703, 867
Total	13, 606, 286	23, 574	13, 629, 860	5, 906, 587

[1] Data from Forest Products, 1928: Lumber, Lath and Shingles. Bureau of the Census, 1930.
[2] Figures based on compiled data in the files of the Forest Service.

The surplus in production over regional requirements in 1928 was 7,723,273 M board feet.

The exceptionally favorable location of many mills at ocean shipping points, and the high quality of the products, facilitate distribution to domestic markets and permit distribution throughout the world. The market possibilities shown by these statistics are slight in contrast with the huge volume of the timber in private ownership, if this is conceived of as available for immediate market. Every thousand feet of timber unprofitably marketed displaces a like quantity that ought to be marketed.

Pulp and paper products, veneers, creosoted piling, and other products are shipped out of the region in large quantities. A large volume of these and other forest products is consumed, also, within the region.

FINANCIAL ASPECTS OF PRIVATE FOREST OWNERSHIP

Col. W. B. Greeley, secretary-manager of the West Coast Lumberman's Association, estimates (*13*) that the 347 billion feet of timber in the Douglas fir region of Washington and Oregon has an investment value of $502,674,500. If the 247 billion board feet of privately owned timber in the pine and redwood types (including also all minor types) of the Pacific Coast States has similar average value, the investment value of all the privately owned timber in the three States approximates $860,000,000. Only in part does this represent actual investment. All the land passed from public into private ownership free or for a few cents per acre with the exception of that disposed of under the Timber and Stone Act, most of which was sold at the rate of $2.50 per acre. The transfer occurred principally during the last quarter of the nineteenth century, through railroad land grants, homesteading, and the Timber and Stone Act. The investment of actual money since acquisition consists in payment of local taxes and of fire-protection and administrative costs. If these costs have amounted to as much as 50 cents per M board feet, the actual money investment may still be less than $300,000,000. These costs have been met largely through proceeds from the sale of timber. The amounts that have been paid to local governments in taxes are in most cases many times the price originally paid to the Federal Government.

Many late comers in the region bought land from the original holders, and these have an actual money investment comparable to the present capitalization rate of the whole. All this capitalization now enters into the balance sheets of individual and corporate owners, and cannot be eliminated or reduced except as a present loss. The maintenance of these values therefore represents a vital problem to thousands of individuals. Maintenance and even increase, if soundly based, is socially valuable, since where there is value care will be exercised. From the standpoint of the public and of the private owners, sound measures will be those that maintain values.

The policy of hasty liquidation of this investment has proved a costly failure, owing to the impossibility of placing this huge volume of timber on the market, in a short time, at a price that would recover all operating costs plus a sufficient depletion charge to return the investment. Large areas in the region are too inaccessible for profitable operation under any combination of price and operating-cost conditions that has yet occurred. Further than this, within the past few years studies of costs and returns from logging and milling operations, of the type described later in this chapter, have proved conclusively that in virtually every type of forest in the region cutting the small trees usually results only in loss. These studies have indicated that in accessible stands not more than 60 percent of the volume is suitable for cutting under cost and price conditions as of 1926 to 1929, and that in all probability less than 50 per cent of the total volume of all stands is operable under conditions of those relatively good years. If this estimate approximates the facts there remains 20 to 25 years' cut, under present economic conditions, of accessible financially mature timber. Under a selective cutting policy it may be necessary to slow down the cut to avoid overburdening the market with high-grade products.

The selective removal of this timber within that period would leave ample time for the remaining trees to grow into such sizes and values as to provide a like cut for the ensuing 20 years. This procedure would constitute a complete reversal of the policies in effect to the present date. It would make unnecessary the recovery, from operations of normal annual volume, of depletion charges which now amount to more than $30,000,000 annually (*12*a). Depletion would remain in some properties. In others, including areas cut over in the past but restocking with new growth and areas on which stands left after selective cuttings are developing, value increases would be accumulating. The history of forest values in other countries warrants the belief that this constructive policy might, if adopted, preserve unimpaired the larger part of the capital values of privately owned forests in the Pacific Coast States.

SAWMILL AND LOGGING INVESTMENTS

Colonel Greeley (*13*) estimates sawmill and logging investments in the Douglas fir region at about $300,000,000. If this ratio of timber investment to operating investments hold throughout the pine and redwood regions as well as the Douglas fir region, the whole investment must be in the neighborhood of $500,000,000. Here again the source of the original capital is of interest. Some of the capital was brought in from other regions. A considerable amount was raised by bonding timber tracts or by borrowing from banks. Past cutting of timber was the source of a large amount. This last is especially true of investment in logging railroads, which can often be paid for currently as they are gradually extended into the timber.

There can be little doubt that one half the existing facilities would supply all requirements of the market, provided a labor supply could be found for operating two or more shifts during the rare periods when lumber markets are very active. Again considerable numbers of low-grade logs are being transported long distances and cut in elaborate mills at high cost although they would yield just as valuable material if cut in low-cost local plants at a great saving of transportation and manufacturing expense and with a lesser capital investment. It is plain that large sums have been expended on manufacturing facilities in such a way as to compel unprofitable timber operations. Furthermore, there is grave danger that such expenditure has not come to an end. Not only have operating facilities been developed in excess of the need, but these facilities are poorly distributed with respect to the Pacific coast forests as a whole. In California and southwest Oregon large bodies of timber in private ownership are not served by any operating facilities.

The sums lost in overdevelopment of operating facilities would unquestionably have been ample to perfect fire protection and other measures of forest perpetuation, and thus to have placed the forests of the region on a sustained-yield basis. This would have meant permanence to the facilities developed, subject of course to ordinary wear and obsolescence.

PULP MILLS, VENEER PLANTS, ETC.

Large sums are invested in pulp and paper mills, veneer plants, etc., particularly in western Washington and in Oregon. Data on the amount of these investments are not at hand. Apparently there is little if any excess investment in these fields on the basis of normal conditions. The veneer plants are able to create from the highest grades of logs a product valued at as much as three times the value of the lumber that could be made from the same logs. Pulp mills usually operate 24 hours per day and make very intensive use of the capital investment. Plants of this type are able to create a high-value product from sawmill waste and from species which heretofore have been nearly worthless. Therefore they contribute to the earnings of the forest investment without increase in capital requirements and are a vital part in the economic welfare of the whole region.

A decrease in utilization of saw timber and a further increase in use of smaller-sized material are needed to eliminate the large waste still occurring. Selective cutting may bring about this balance without the necessity of further development of forms of utilization, providing definite coordination is established among the different forms of utilization.

AVERTING FURTHER OVERDEVELOPMENT OF MILL CAPACITY

Although manufacturing facilities are already overdeveloped there is grave danger that the first active lumber market will bring about establishment of mills to serve the nonoperated timber mentioned above. Two possible methods of deferring such development seem particularly feasible. The first and perhaps the simplest would be to return these areas to public ownership under conditions that would protect the communities concerned. Payment in such case might be in special bonds bearing from 2 to 4 percent interest. A method of handling such purchases has been outlined by L. F. Kneipp (*14*).

The second method is to rely on private initiative to proceed on a basis of planned action that will take into full consideration the economic situation of the forest industries as a whole and of the West in particular. This would involve consolidating these areas into sustained-yield units of 20,000 to 100,000 acres each, well planned from the standpoint of topography and transportation outlets. These units, it must be recognized, would not be ready for immediate operation at their full capacity. They would be made up of cheap stumpage that should be held until market pressure is relieved by the discontinuance of numerous operations owing to exhaustion of their raw material. Future operating plans would contemplate a rate of cutting only equal to the sustained yield of the properites. Above all, the overdevelopment and consequent waste of capital which have characterized most of the localities opened up in the past should be avoided. Where possible, the safe and conservative business of forest ownership and management should be kept distinct from the entirely different and rather risky business of manufacturing and selling. The two lines require very different managerial abilities and have rarely been combined successfully.

These suggestions contemplate an ordered management, starting with virgin forest, in which capital is not wasted by overdevelopment of plant facilities nor productivity destroyed by removal of the growing stock. Under this policy it can be expected that in nearly every case some cutting will be necessary to meet local needs and that in a very few years demand will grow to larger proportions. Where income cannot be obtained immediately to meet current expenses it will be necessary to have access to financial reserves or credit facilities, as discussed elsewhere in this report.

MANAGING PACIFIC COAST TYPES TO MAINTAIN PRODUCTIVITY

DOUGLAS FIR FORESTS OF WESTERN OREGON AND WASHINGTON

The specific measures desirable in Douglas fir forests can be better understood by considering the distribution of size classes in typical stands. Figure 4 shows for an old-growth Douglas fir stand of meduim quality in Oregon the cubic volume, by diameter classes, on an average acre (*15*). The stand is about 80 percent Douglas fir, which includes the larger tree sizes, and 20 percent western hemlock.

Figure 4 also indicates approximately the quantity of timber of each diameter class that should be removed in the first cutting. The guiding diameter limit of 40 inches is based on the knowledge that from about 40 to 60 percent of the volume of the older virgin stands in the region is in diameter classes above that size; that these trees can be logged and manufactured the most cheaply; and that they will yield the highest-value lumber and therefore by far the highest net stumpage. They are the most subject to deterioration if not logged, and are in general decaying at a rate equal to or exceeding the gross volume growth of the stand. Some trees in thrifty condition over 40 inches may well be left standing, and trees under that limit but not of a character to make net growth should be removed wherever that can be done at a moderate profit.

In these stands the larger trees are generally found in groups, and such selection will result in clear cutting on from 5 to 15 percent of the area in each cutting cycle. The resultant open spots will provide suitable conditions for regeneration of Douglas fir which, except in the fog belt and at high altitudes, is usually the most desired species. Complete slash disposal by the methods common in the region will usually be practiced on these spots. Either sufficient Douglas fir seed trees must be left to seed in an adequate proportion of fir on these spots or wide-spaced planting may be necessary as discussed under the spruce-hemlock type. The total number of trees removed will hardly exceed 6 to 8 per average acre. About 40 to 60 trees from 6 to 40 inches in diameter will remain; except for the open spots noted, the forest cover will be very slightly disturbed.

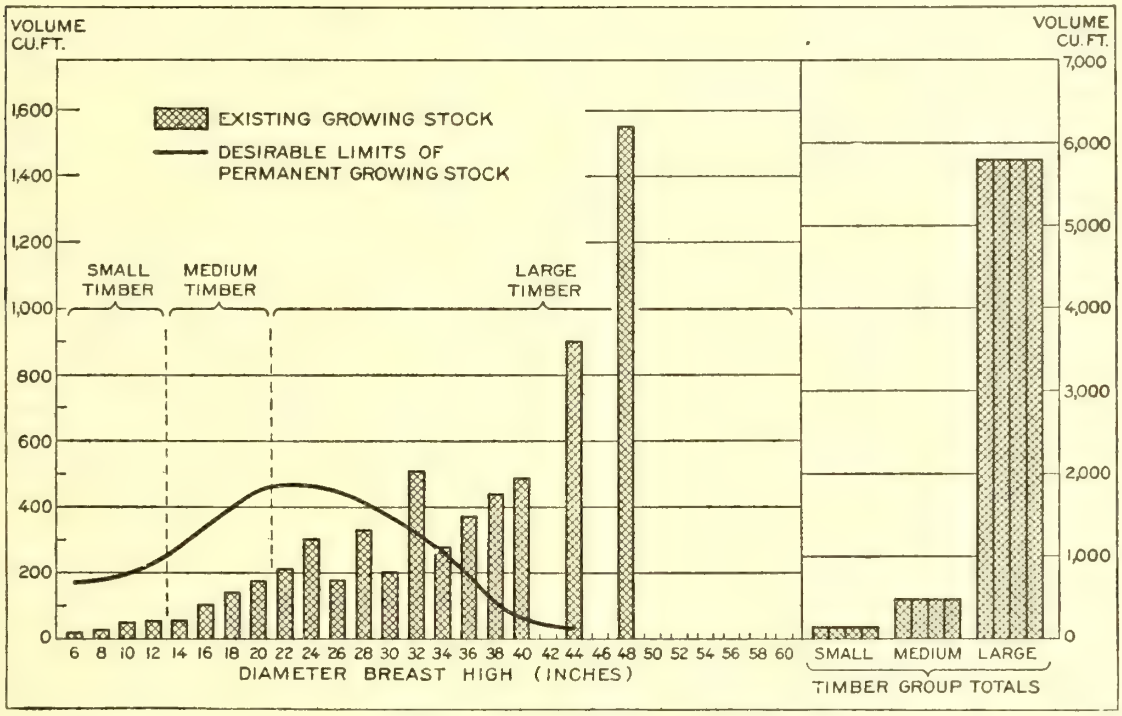


Figure 4.—Distribution of cubic volume by diameter classes on average acre, old growth Douglas fir with hemlock, western Oregon.

The residual stand will be in shape to accelerate its growth, especially in the lower diameter classes, which will be mainly hemlock. Although no precise data are available from such cuttings, it is known that hemlock accelerates its growth rapidly when released from crown and root competition. A net current annual growth of 400 to 800 board feet per acre can reasonably be counted on when the growth of the smaller tree classes increases. If the first cut passes over the whole forest property in 20 years, the second cut can begin immediately afterward in stands rebuilt to about 30,000 board feet per acre. The second cut should not greatly exceed the rate of growth during the cutting cycle, or about 10,000 feet per acre. The decision as to the quantity of timber to be removed in that cut should, however, be deferred until the time for the cut has come. It may then be desirable either to remove more of the growing stock or to rebuild it to some extent.

Under this procedure the returns from about 20,000 feet per acre of the first cut might be applied to the construction of permanent improvements required by an operating forest property and to partial liquidation of the capital investment. At the end of the first 20 years' cutting period the liquidation phase would be practically completed and the remaining stand would constitute approximately the growing stock necessary for a continuously operated sustained-yield property producing at an average rate of 500 board feet or more per acre. Such a property will produce stumpage at a current cost for taxes, administration, and protection not far from $1 per M board feet.

The cost of production per 1,000 board feet in Douglas fir properties is, therefore, less than the accumulated investment per 1,000 board feet in many tracts of virgin stumpage, even exclusive of the values written into such stumpage. The cost differential against virgin stumpage as compared with currently produced stumpage will increase. The possibility of earnings on the investment depends, as in any other business, on the margin between the cost of producing the stumpage and the returns that can be realized on it.

The application of these methods presupposes organized operations on tracts sufficiently large to permit annual cutting operations on an efficient scale. Tracts of 20,000 to 100,000 acres present optimum conditions for such enterprises, being large enough for efficient operation but not so large that the managers will be likely to overlook details of management. In assembling such tracts it should be remembered that over 4 million acres in the Douglas fir region have been clear cut to date. Each operating property can carry a cut-over area equal to the timbered area, especially if regeneration has already taken place on the cut-over area. Even if a little planting is required the cost will not be burdensome to the project as a whole.

Frequently the growth of young stands will justify more rapid cutting of mature stands and will thus increase the current net returns from the property. A proportion of cut-over area such as that suggested represents a very small proportion of the investment. It can be relied on under good management to earn a low rate of compound interest in the form of an increase in capital value throughout the period of rebuilding the stands. Mixed stands of Douglas fir and hemlock coming up in the open spots left by early cuttings will at 30 to 40 years of age be ready for the first of the thinnings that will provide pulpwood, which is expected to be in permanent demand in the region. These stands as they approach maturity should be managed in a way to prolong the rotation, some of the trees being left to grow to large sizes. Early cuttings in these stands will produce as large quantities of poles, posts, tie timber, and similar materials as the market is likely to require. Later cuttings will yield high-grade saw timber. The presence of extensive young stands which even if conservatively managed will contribue a large quantity of low-grade material to the market, greatly facilitates maintenance of supplies of larger timber in the old stands suitable for the special market demands on the Pacific coast forests.

Although economic and other factors brought out in this discussion warrant placing great stress on selective-cutting practices, it is recognized that Douglas fir stands can be regenerated even if clear cutting is practiced on larger areas than suggested above. On a few tracts the timber is of such uniformly high value that selective cutting is not economically feasible. Certain topographic conditions, also, necessitate clear cutting over considerable areas. Where larger continuous areas are cut within a short time fire protection is much more difficult. Fire once started is apt to sweep through the crowns of young stands at any ages under 30 or 40 years. Even surface fires are difficult to control on large areas of young stands. In the section of this report entited, "How to Stop Forest Devastation", methods followed in clear cutting on larger areas are described. The subject is discussed in detail also by Mr. Thornton T. Munger in a bulletin contributed from the Pacific Northwest Forest Experiment Station (*16*).

Table 7.—*Number of trees, volume, and growth in a typical young Douglas fir stand about 110 years of age in western Washington*

Tree diameters at breast height	Trees per average acre				Time required to grow to next diameter class			Cubic volume			
	Douglas fir	Cedar	Hemlock	Total stand	Douglas fir	Cedar	Hemlock	Douglas fir	Cedar	Hemlock	Total
Small timber:	*Number*	*Number*	*Number*	*Number*	*Years*	*Years*	*Years*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*
6 inches	1.17	2.53	1.37	5.07	9	31	31	8.13	9.36	5.07	22.56
8 inches	1.23	1.77	1.10	4.10	6	27	27	16.36	13.88	8.62	38.86
10 inches	1.13	2.00	1.10	4.83	3	21	21	22.71	23.60	20.06	66.37
12 inches	1.90	1.93	2.07	5.90	35	16	16	53.77	38.60	41.40	133.77
Total	5.43	8.23	6.24	19.90				100.97	85.44	75.15	261.56
Medium timber:											
14 inches	1.70	1.93	.77	4.40	31	12	12	71.91	51.34	20.48	143.73
16 inches	1.87	1.30	.60	3.77	27	9	9	100.79	44.07	20.34	165.20
18 inches	2.20	1.10	.73	4.03	22	7	7	156.86	53.24	35.33	245.43
20 inches	2.77	.93	.70	4.40	18	6	6	255.12	60.91	45.85	361.88
Total	8.54	5.26	2.80	16.60				584.68	209.56	122.00	916.24
Large timber:											
22 inches	2.40	.57	.60	3.57	15	6	6	259.20	43.89	46.20	349.29
24 inches	2.70	.63	.46	3.79	13	6	6	332.10	56.07	40.94	429.11
26 inches	2.78	.90	.33	4.01	12	7	7	417.00	99.90	36.63	553.53
28 inches	3.20	.80	.20	4.20	10	9	9	579.20	108.00	27.00	714.20
30 inches	1.36	.50	.06	1.92	10	11	11	272.00	74.50	8.94	355.44
32 inches	1.50	.17	.10	1.77	9	14	14	361.50	29.75	17.50	408.75
34 inches	1.86	.17	.10	2.13	9	17	17	537.54	34.68	20.40	592.62
36 inches	1.56	.43	.07	2.06	10	21	21	522.60	102.77	16.73	642.10
38 inches	1.16	.13	.10	1.39	11	25	25	455.88	36.27	27.90	520.05
40 inches	1.03	.20	.03	1.26	12	29	29	433.63	59.60	8.94	502.17
42 inches	.60	.27	0	.87	12	34		268.80	92.61		361.41
44 inches	.37	.13	.03	.53	13	38	38	193.14	47.06	10.86	251.06
46 inches	.23	.13		.36	15	44		127.19	49.66		176.85
48 inches	.27	.17		.44	16	49		173.61	75.14		248.75
50 inches	.33	.10		.43	17	55		244.86	46.40		291.26
Total	21.35	5.30	2.08	28.73				5,178.25	956.30	262.04	6,396.59
Total for average acre	35.32	18.79	11.12	65.23				5,863.90	1,251.30	459.19	7,574.39

Tree diameters at breast height	Saw timber volume				Average annual growth of saw timber [1]			
	Douglas fir	Cedar	Hemlock	Total	Douglas fir	Cedar	Hemlock	Total
Small timber:	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
6 inches	30	20	30	80	3	5	3	11
8 inches	60	250	30	340	10	1	1	12
10 inches	110	320	70	500	22	2	1	25
12 inches	280	340	180	800	3	3	3	9
Total	480	930	310	1, 720	38	11	8	57
Medium timber:								
14 inches	340	390	130	860	4	3	1	8
16 inches	510	290	160	960	8	9	4	21
18 inches	850	310	300	1, 460	16	8	5	29
20 inches	1, 510	310	380	2, 200	27	24	18	69
Total	3, 210	1, 300	970	5, 480	55	44	28	127
Large timber:								
22 inches	1, 730	280	420	2, 430	37	18	19	74
24 inches	2, 570	430	420	3, 420	61	21	15	97
26 inches	3, 460	790	370	4, 620	70	30	11	111
28 inches	4, 950	890	270	6, 110	96	20	5	121
30 inches	2, 510	670	110	3, 290	48	11	1	60
32 inches	3, 300	270	190	3, 760	62	4	2	68
34 inches	4, 780	320	230	5, 330	69	4	2	75
36 inches	4, 530	960	180	5, 670	62	8	1	71
38 inches	3, 830	340	300	4, 470	47	1	1	49
40 inches	3, 860	570	120	4, 550	43	2	1	46
42 inches	2, 550	860	------	3, 410	20	4	------	24
44 inches	1, 720	480	150	2, 350	17	1	------	18
46 inches	1, 210	530	------	1, 740	4	1	------	5
48 inches	1, 490	730	------	2, 220	7	2	------	9
50 inches	2, 660	480	------	3, 140	8	1	------	9
Total	45, 150	8, 600	2, 760	56, 510	651	128	58	837
Total for average acre	48, 840	10, 830	4, 040	63, 710	744	183	94	1, 021

[1] Data on rate of tree mortality were not taken. Net growth per acre may not exceed 75 percent of total growth shown.

In addition to the old-growth stands and the young stands that have developed following lumbering operations, there are in the Douglas fir region considerable stands of timber 40 to 150 years old which originated after fires. Stands that have reached an age of about 100 years can be cut in a manner similar to that recommended for old stands with about the same results except for two factors: The material removed will not yield much clear lumber, but will be uniformly sound, and will be excellent for structural timber; and, the residual stand will consist very largely of Douglas fir and will be in better condition to make rapid growth. Figure 5 and table 7 represent the conditions in a stand varying from 80 to 120 years of age (*17*). A few old veterans and a few groups of young trees are present in this stand, and cutting will be to a slightly lower diameter limit. About 30,000 board feet per acre will be removed and about 30,000 board feet left. Some groups will be cut clear to permit Douglas fir reproduction; the remaining stand will be managed for from 40 to 60 years longer, with cuttings about every 20 years.

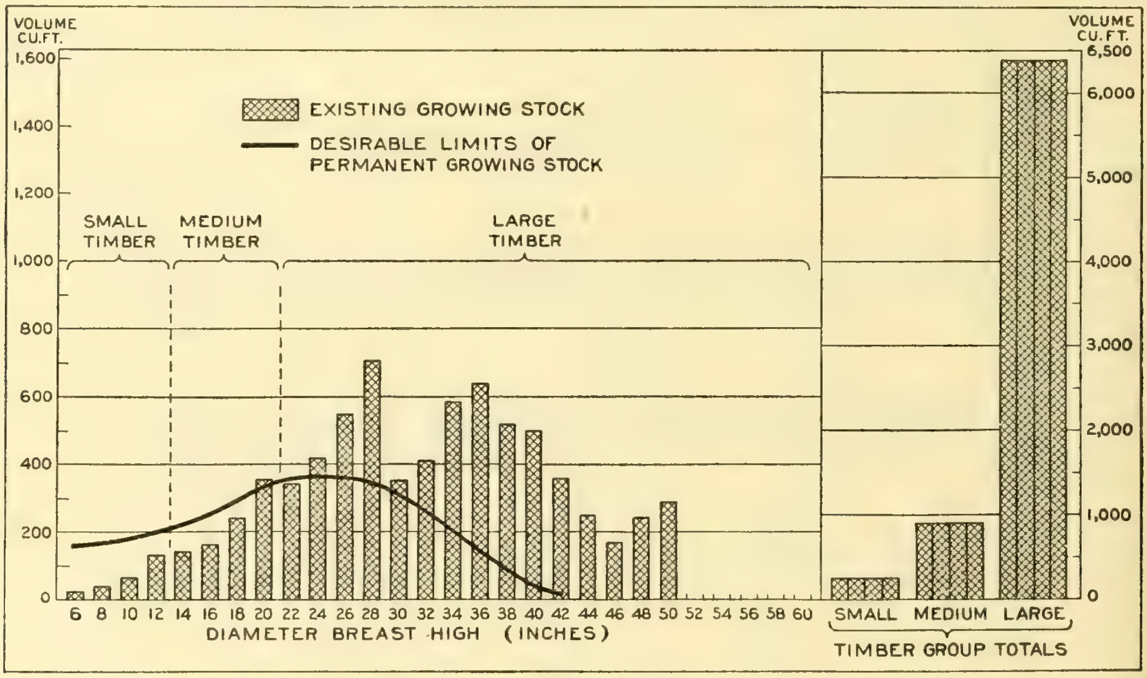


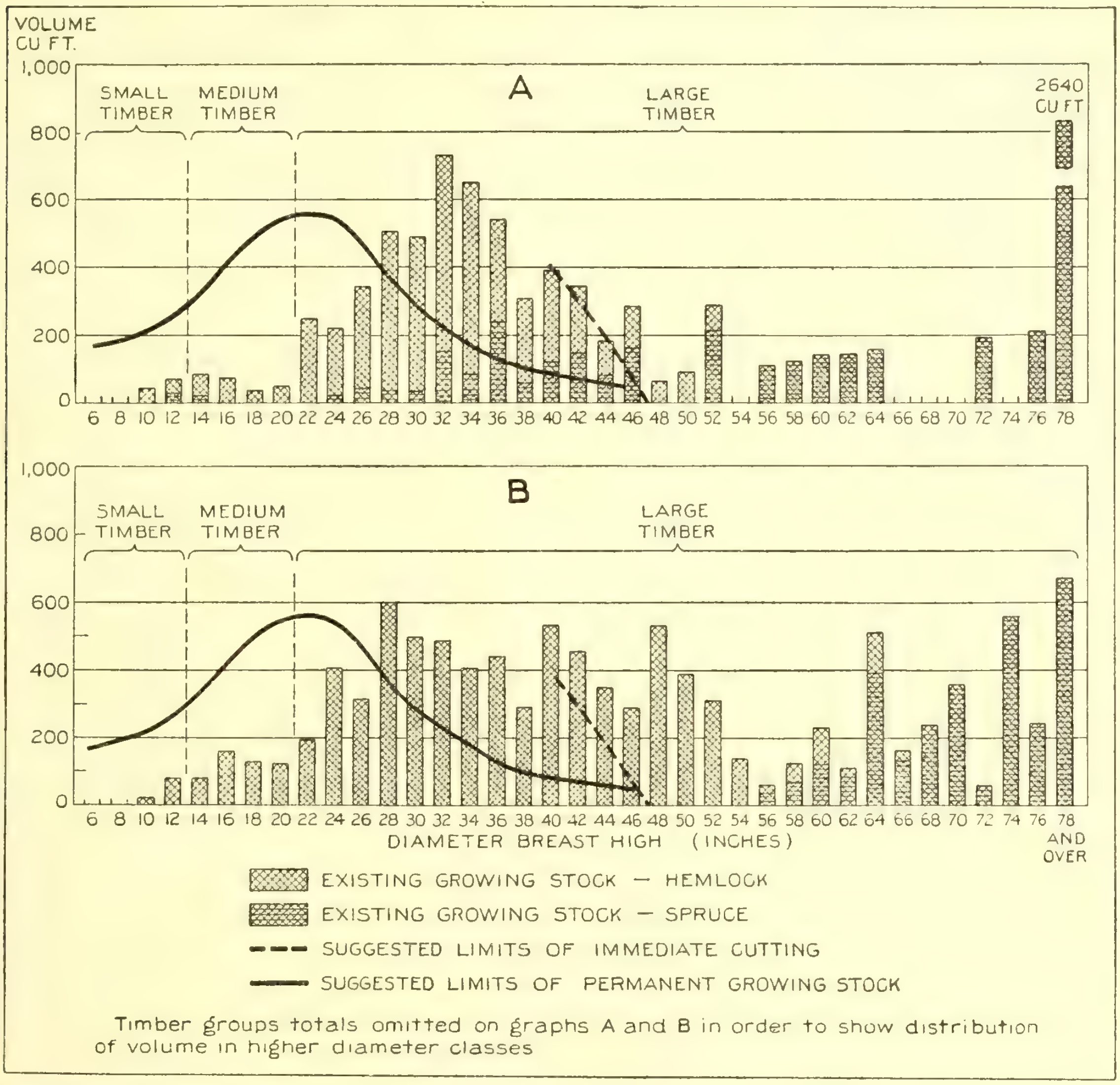
FIGURE 5.—Distribution of cubic volume by diameter classes on average acre, 80- to 120-year-old Douglas fir with a few old veterans (48- and 50-inch classes) and a subordinate stand of western hemlock and western red cedar.

Spruce-hemlock forests occur in a limited area known as the "fog belt" along the Oregon and Washington coasts. As Douglas fir, also, occurs to some extent in this belt, the area is considered part of the Douglas fir region. These particular forests present a remarkable example of two forest stands, of widely separated age classes, growing on the same area. The first constituent is the old spruce, ranging to 110 inches in diameter and probably 600 to 800 years old. This undoubtedly had a high percentage of even-aged hemlock associated with it at the start. As hemlock usually does not live to more than 300 years of age the hemlock stand has gradually changed to all-aged form, and now exists and develops almost independently of the presence of the few remaining spruce trees. The spruce stand includes most of the immediate realization values.

Figure 6 shows cubic-volume distribution by diameter classes on average acres for two closely adjacent areas in the lower Columbia

River region (*18*). On such areas it is recommended that the first cutting take the diameter classes to the right of the broken lines on the diagrams, which include all diameters above an average of about 44 inches. The reasons for this limit on cutting, brought out by an intensive investigation during 1932 of results of logging on these areas, are as follows:

1. If logging is confined to these limits the net stumpage realized in the Columbia River log market, even in the depression year of 1932, exceeds $6 per M board feet. The remaining diameter classes, consisting mostly of hemlock, will net considerably less than $2 per M board feet. Figure 7 shows the margin between log prices and logging costs for the spruce and hemlock, respectively.



Timber groups totals omitted on graphs A and B in order to show distribution of volume in higher diameter classes

FIGURE 6.—Distribution of cubic volume by diameter classes on average acre in two typical spruce-hemlock stands, lower Columbia River region. A, Some spruce occurs in lower diameter classes: 5,550 cubic feet of spruce, 5,120 cubic feet of hemlock per acre; B, All spruce is 56 inches or more in diameter: 2,970 cubic feet of spruce, 7,820 cubic feet of hemlock per acre.

2. In these old trees the otherwise merchantable portion of the bole already averages 35 percent defective. The trees are losing much more volume than the hemlock stand can grow; in fact, the growth of he hemlock is offset by the constant dropping out of hemlock trees reaching the age limit.

3. Cutting the spruce and some of the largest hemlock will give he smaller-sized hemlock a chance to develop. This will prepare the

way for the second cut, which will eliminate the remaining defective hemlock and leave a stand of adequate volume.

If only trees of the diameter classes to the right in the diagram for stand A are removed in the first cutting, as recommended, there will remain spruce seed trees to help seed the small areas cut clean in the first cutting. In stand B there is no spruce less than 56 inches in diameter and no seed will be available for the openings left by cutting. Wide-spaced planting (15 by 15 feet) with strong stock can be carried on at low cost and should assure spruce in the future stand. (Or fir and cedar can be used in the same manner.) The intervening space will fill with a dense stand of hemlock, which will insure natural pruning of the stand but will be sufficiently behind the spruce in development to permit survival of most of the latter. Hemlock reproduction will also come up abundantly within all small openings where single tree cuttings take place. Since hemlock is a valuable pulp species it can readily be removed in periodic thinnings from the time the young groups reach an age of 30 to 40 years. By these thinnings a constant increase can be brought about in the proportion of spruce in the stand.

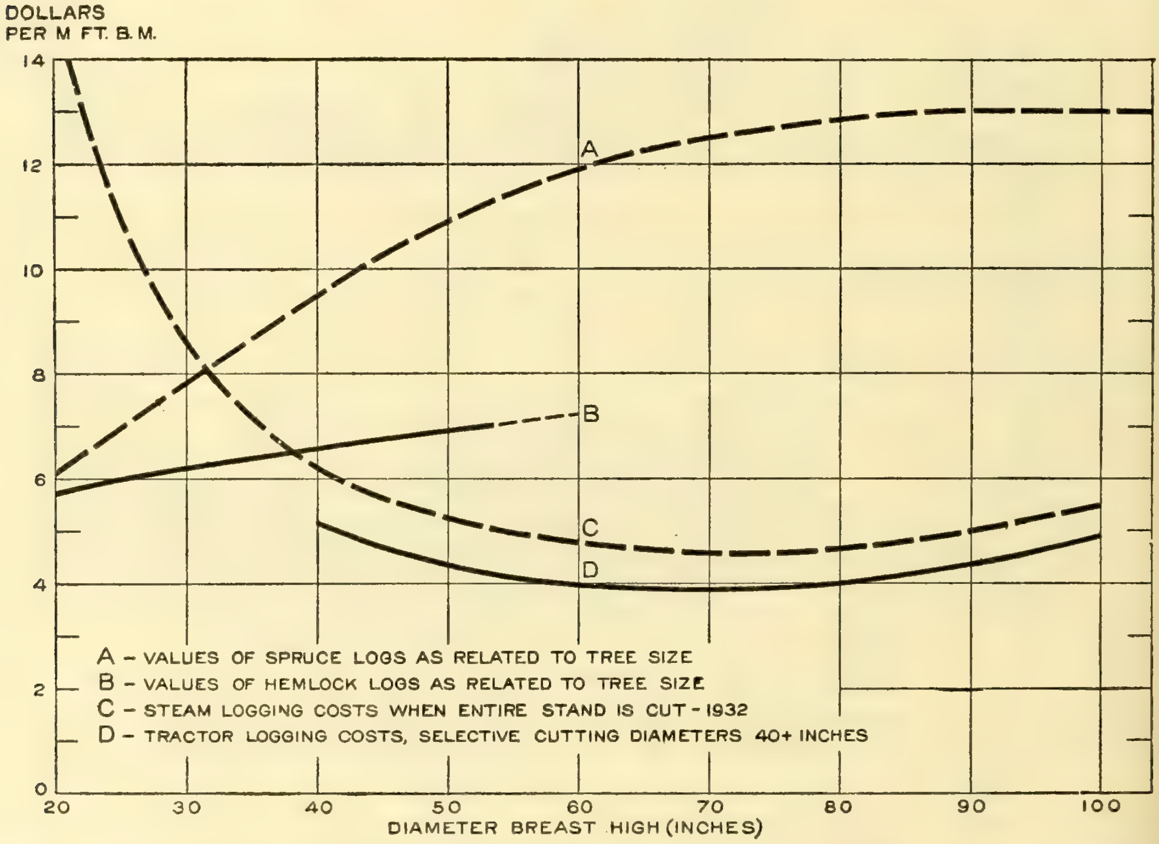


FIGURE 7.—Comparison of log prices (1932 log market) and logging costs, spruce and hemlock, Columbia River region, 1932.

In studies of the present year, two alternative methods have been worked out for logging an 80,000-acre tract in this type which bears about 3 billion feet of timber.

The first method assumes using the liquidation method ordinarily applied in the region and the ordinary machinery, cutting at the rate of 100 million board feet per year, and destroying everything as operations proceed. Under this method the Columbia River market (1932) value of the average log produced on this operation is $9.71 per M board feet. With logging costs deducted the net stumpage realization value is $3 per 1,000 board feet, giving a gross stumpage return of $300,000 per year.

Assuming a $3,000,000 debt against the tract, bearing 6 percent interest, will make it representative of the region. With the $300,000 a year applied to taxes (2 cents per M board feet on the timber standing, which equals $60,000 the first year and diminishes as timber is cut) and to interest ($180,000 the first year and diminishing as principal of debt is paid), and to principal ($60,000 the first year) it will take till 1956 to liquidate the debt. The income from a little more than 6 years' cut belongs to the operator. Discounted to present value at 6 percent interest, it yields an equity in the tract worth $454,130.

The second method involves liquidating high-value stumpage at the rate of 100 million board feet a year for 15 years. After that the cut is to be dropped to 50 million board feet a year on a sustained-yield basis. The average log value from trees over 40 inches such as will be cut the first 15 years is $11.34 per M board feet and the net stumpage realization, with tractor instead of steam logging, is $6.08 per M board feet (1932 depression prices and costs). For the first 15 years $608,000 a year is available to pay taxes and retire debt. After 15 years the income will be reduced both because of reduction in cut and because of lower value of material. Taxes are as under the other method except that they are cut down faster by removing high values, and the debt is entirely retired by 1938. The income from 1938 to 1962 belongs to the operator (except for tax deduction). Discounting these values at 6 percent to present value gives the result $2,821,924. In addition there will remain after 1962 a sustained-yield forest yielding 50,000,000 board feet per year.

It must be admitted that the tract on which these calculations are based is unusually well situated, close to deep water, but the principles involved apply in like manner to most of the remaining large tracts of virgin timber in the Douglas fir region. The returns will vary, but in virtually every case liquidation is the surest method devised for destroying values.

Although it seems self-evident that an operating method which in a few years destroys the current productivity of a tract capable, as in this case, of producing a sustained yield of 50,000,000 board feet per year must destroy large financial values, definite and reliable figures showing the real extent of such losses have hitherto been lacking. The figures presented here, since they are based on depression conditions, are undoubtedly ultra conservative both for liquidation values and for sustained-yield values.

COAST REDWOOD FORESTS

The coast redwood forests present problems similar to those of the Douglas fir forests. Lower-value species are associated with the redwood, so that the value of individual trees, varying both with size nd with species, has a very wide range. These forests contain such a reat proportion of large fine-quality trees that a selective logging ractice partly on a group and partly on a single-tree basis is indicated hich will permanently liquidate perhaps one half the capital value. he remaining growing stock would support at least the major portion f the investments in logging railroads, mills, and towns. Any comlete liquidation policy would lead to proportionately greater capital sses in this region that in the Douglas fir region. No stand table is vailable for this type.

SUGAR PINE AND PONDEROSA PINE FORESTS (WITH OTHER CONIFERS)

The sugar pine and ponderosa pine forests (with other conifers in mixture) also present problems similar to those of the Douglas fir forests, except that logging operations are frequently more expensive and that the range of values is greater owing to the high values of high-grade sugar pine and ponderosa pine lumber. Logging practice has already been modified in some cases to provide for leaving a residual stand, but the present practice seriously decreases the percentage of pine in the stand and in some instances removes no white fir or incense cedar. Recent studies indicate that a much greater volume of pine should be left in the stand, for two reasons: First, the pine of smaller diameters is unprofitable to log; second, a larger growing stock will provide for greater production per acre. The guiding diameter limit indicated for selecting trees to be cut is from 36 to 44 inches.

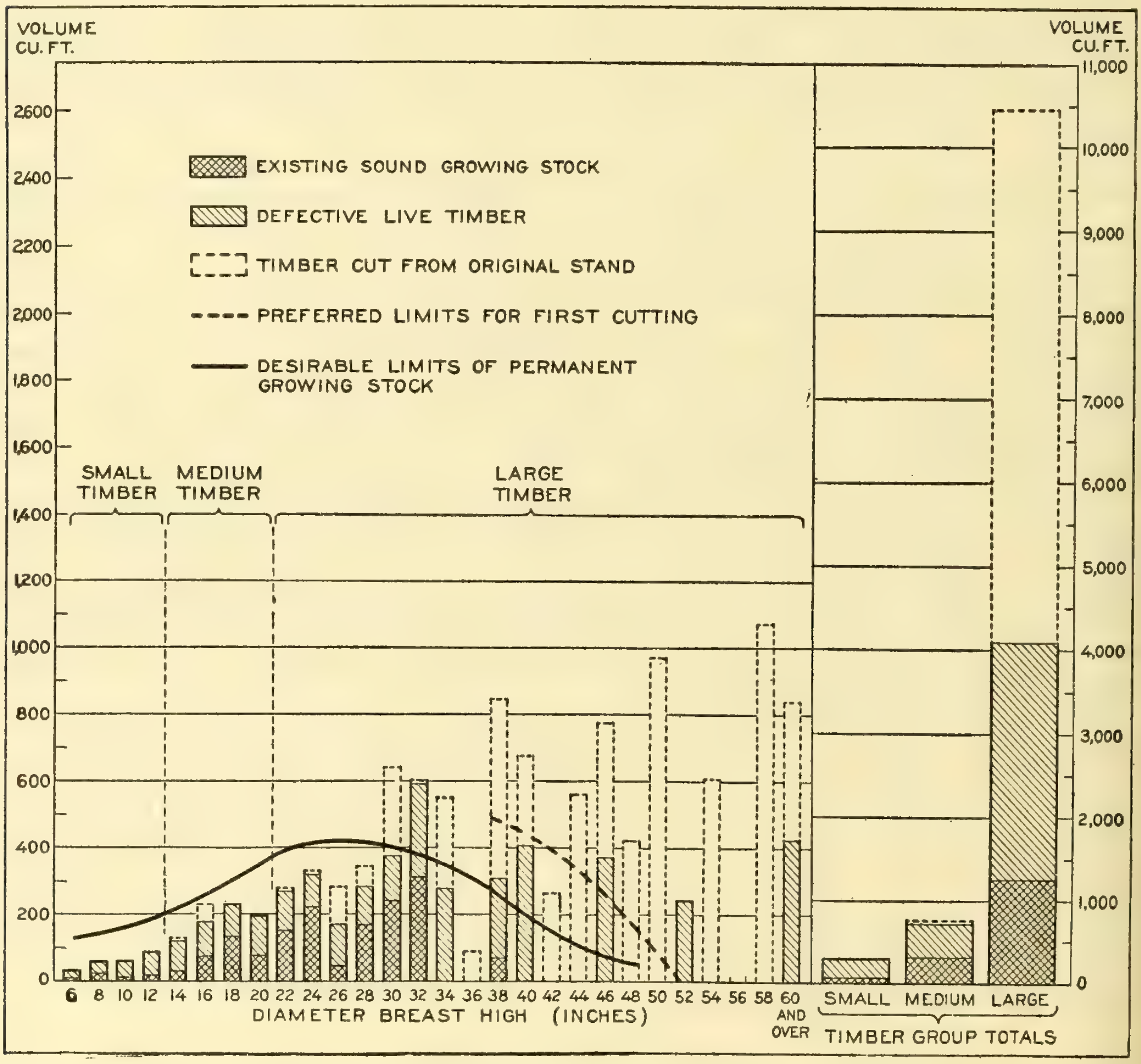


FIGURE 8.—Distribution of cubic volume by diameter classes on average acre before and after cutting in virgin stand of sugar pine and other conifers in California.

Figure 8 and table 8 represent a typical stand on private lands as it existed before lumbering operations, and the sound and defective growing stock left after lumbering (*19*). The broken line shows the approximate point to which it seems the first cut should have been made, and the solid line shows an approximation to the stand that eventually might be accepted as satisfactory permanent growing stock. If the stand is cut in this way, a high stumpage rate will be realized on the current cut and the lower-value diameter classes will be preserved for further growth in volume, quality, and value.

[illegible] volume, and growth in a typical stand of sugar pine, with other conifers in California

Tree diameters at breast height	Trees per average acre						Time required to grow to next diameter class					Cubic volume					
	Sugar pine	Ponderosa pine	Douglas fir	White fir	Incense cedar	Total stand	Sugar pine	Ponderosa pine	Douglas fir	White fir	Incense cedar	Sugar pine	Ponderosa pine	Douglas fir	White fir	Incense cedar	Total
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Years*	*Years*	*Years*	*Years*	*Years*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
Young stock: 4 inches	1.25		1.00	4.00		6.25	11		25	22		1.2		1.2	4.0		6.4
Total	1.25		1.00	4.00		6.25						1.2		1.2	4.0		6.4
Small timber:																	
6 inches	1.25	.50	.75	5.00	.75	8.25	8	10	18	13	14	4.3	0.8	2.3	15.0	1.7	24.1
8 inches	.75	.25	.50	5.25	.75	7.50	8	9	14	11	12	5.7	1.9	4.4	35.7	3.6	51.3
10 inches	.50			4.00	.75	5.25	7	8		10	12	8.0			51.2	7.0	66.2
12 inches	.50	.25		3.00	.75	4.50	6	8		9	11	5.8	6.2		65.1	11.8	88.9
Total	3.00	1.00	1.25	17.25	3.00	25.50						23.8	8.9	6.7	167.0	24.1	230.5
Medium timber:																	
14 inches				3.50	0.75	4.25		7		8	11				119.7	10.5	130.2
16 inches	.25			2.75	.50	3.50	6	7		8	11	11.8			139.7	20.1	171.6
18 inches	.50	.25		1.50	1.50	3.75	6	7		8	12	32.8	19.2		106.4	73.5	231.9
20 inches	.75			1.00	.50	2.25	5	8		9	12	65.8			94.9	31.3	192.0
Total	1.50	.25		8.75	3.25	13.75						110.4	19.2		460.7	135.4	725.7
Large timber:																	
22 inches	.25	.25	.25	.75	1.00	2.50	5	8	13	9	13	28.5	33.7	32.5	92.5	80.4	267.6
24 inches	.25			1.75	.25	2.25	5	8		11	13	36.5			269.9	24.9	331.3
26 inches	.25			1.25	.25	1.75	5	8		10	14	45.2			239.0	30.4	314.6
28 inches			.50	1.00		1.50		8	13	10				116.4	229.3		345.7
30 inches	1.25			1.00	.25	2.50	5	8		10	17	327.5			271.6	43.2	642.3
32 inches	.50			1.25	.25	2.00	6	8		10	17	151.2			398.3	50.6	600.1
34 inches	.25		.25	1.00		1.50	6	8	14	9		89.4		91.4	370.3		551.1
36 inches	.50					.50	6	8				104.0					104.0
38 inches		.50		1.00	.25	1.75		8		9	18		290.7		479.1	79.2	849.0
40 inches	.25			1.00		1.25	8	9		12		136.0			541.7		677.7
42 inches	.25				.25	.50	8	10			20	156.0				101.0	257.0
44 inches	.50	.25				.75	9	10				355.0	290.5				645.5
46 inches	.50			.50		1.00	10	11		14		400.0			375.6		775.6
48 inches	.25		.25			.50	11	12	18			222.1		204.2			426.3
50 inches	.75		.25			1.00	12	13	18			738.8		232.3			971.1
Total	5.75	1.00	1.50	10.50	2.50	21.25						2,790.2	614.9	676.8	3,267.3	409.7	7,758.9
Total for average acre	11.50	2.25	3.75	40.50	8.75	66.75						2,925.6	643.0	684.7	3,899.0	569.2	8,721.5

TABLE 8.—*Number of trees, volume, and growth in a typical stand of sugar pine, with other conifers in California*—Continued

Tree diameters at breast height	Saw timber volume						Average annual growth of saw timber [1]					
	Sugar pine	Ponderosa pine	Douglas fir	White fir	Incense cedar	Total	Sugar pine	Ponderosa pine	Douglas fir	White fir	Incense cedar	Total
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
Small timber: 12 inches	34	32		348	16	430	1	1		5	1	8
Total	34	32		348	16	430	1	1		5	1	8
Medium timber:												
14 inches				517	32	549				35	3	38
16 inches	38			567	34	639	2			17	1	20
18 inches	112	70		402	165	749	9	2		21	8	40
20 inches	238			370	79	687	12			9	2	23
Total	388	70		1, 856	310	2, 624	23	2		82	14	121
Large timber:												
22 inches	105	137	132	508	216	1, 098	10	6	2	17	10	45
24 inches	142			1, 176	70	1, 388	6			21	2	29
26 inches	193			1, 110	90	1, 393	7			19	2	28
28 inches			532	1, 114		1, 646			5	31		36
30 inches	2, 321			1, 376	146	3, 843	80			32	3	115
32 inches	750			2, 085	181	3, 016	19			29	2	50
34 inches	449		614	2, 000		3, 063	11		4	29		44
36 inches	1, 060					1, 060	53					53
38 inches		1, 642		2, 680	308	4, 630		24		41	3	68
40 inches	725			3, 068		3, 793	29			77		106
42 inches	854				409	1, 263	31				7	38
44 inches	1, 975	1, 226				3, 201	29	13				42
46 inches	2, 278			2, 204		4, 482	28			20		48
48 inches	1, 301		1, 252			2, 553	27		4			31
50 inches	4, 395		1, 608			6, 003	362		5			367
Total	16, 548	3, 005	4, 138	17, 321	1, 420	42, 432	692	43	20	316	29	1, 100
Total for average acre	16, 970	3, 107	4, 138	19, 525	1, 746	45, 486	716	46	20	403	44	1, 229

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[1] Losses from tree mortality and by wood-rotting fungi may entirely offset the gross rate of growth shown. This growth data is of interest to show the growth possibilities of this type under management which gradually eliminates the defective and over-mature trees from the stand.

Handling the white fir in these stands is a difficult problem. Undoubtedly this cutting method will leave more white fir on the ground than the silviculturist would advise. It is worth bearing in mind that the operating methods here contemplated involve construction of a minimum of railroad line, of which as much as possible will be permanent. The tractor roads over which the first cut is skidded out will be usable at any later time. It is suggested that under these conditions, when an active market occasionally occurs the operator can readily go back and at very low cost remove more of the white fir. Where this measure does not sufficiently favor the pine, removal of the fir has to be accomplished by logging sizes below the profitable cutting limit.

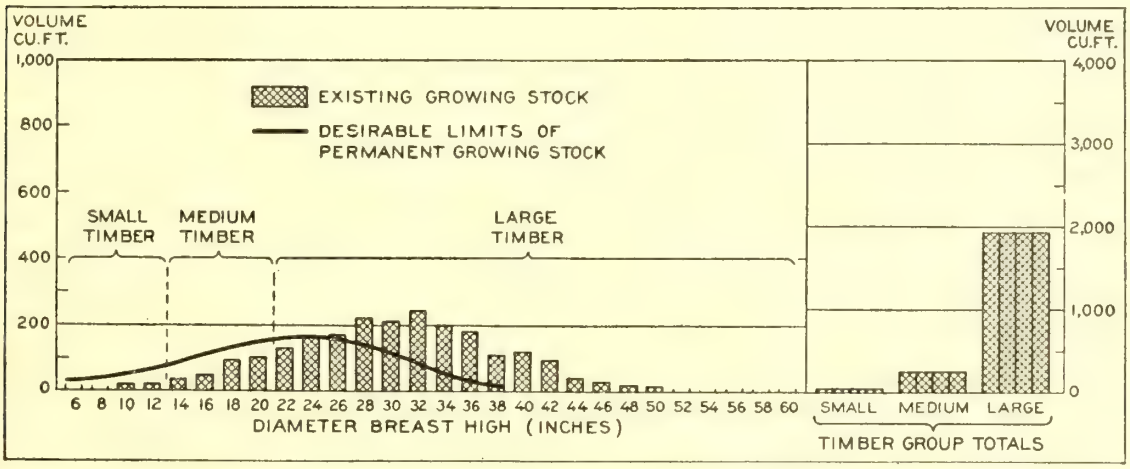

FIGURE 9.—Distribution of cubic volume by diameter classes on average acre, virgin stand of Ponderosa pine in eastern Oregon.

PONDEROSA PINE FORESTS IN OREGON, EAST OF CASCADE MOUNTAINS

The ponderosa pine type of eastern Oregon, extending northward into Washington and southward into California, exists in a region of lighter rainfall than the types just described. The stands are therefore lighter and the growth much slower than in the stands shown in figures 4 to 8. As in those forests, cutting has usually been too heavy. Figure 9 and table 9 show the distribution of diameter classes and volume in a typical stand. Management problems in forests of this type are somewhat different from those in the Pacific coast localities of adequate rainfall. The growth is slow, and some observers believe it may prove necessary eventually to carry in public ownership much of the forest area in this type on which combinations of forest production with grazing or other land uses are not worked out. The measure immediately needed is to discontinue the cutting of small, unprofitable trees and through saving these for further growth to prolong the cut and hence the utility of the dependent mills.

TABLE 9.—*Number of trees, volume and growth in average stocked virgin stand of ponderosa pine in eastern Oregon*

Tree diameters at breast height (inches)	Trees per average acre	Time required to grow to next diameter class	Cubic volume	Saw timber volume	Average annual growth of saw timber[1]
Small timber:	*Number*	*Years*	*Cubic feet*	*Board feet*	*Board feet*
10	2.39	28	21.6	95	----------
12	1.91	28	21.4	94	1
Total	4.30	----------	43.0	189	1
Medium timber:					
14	2.01	25	40.0	176	2
16	1.62	25	52.0	232	3
18	1.88	25	96.0	423	1
20	1.47	25	104.0	465	5
Total	6.98	----------	292.0	1,296	11
Large timber:					
22	1.64	25	131.6	735	3
24	1.53	33	168.4	940	5
26	1.20	40	172.9	965	3
28	1.23	33	220.3	1,230	4
30	.92	40	212.3	1,185	8
32	.90	50	248.1	1,385	4
34	.59	50	197.0	1,100	4
36	.48	50	184.5	1,030	4
38	.37	50	118.2	660	5
40	.34	50	121.8	680	5
42	.23	50	94.0	525	8
44	.06	50	39.3	220	6
46	.05	50	25.0	140	6
48	.02	50	21.1	118	6
50	.02	50	15.5	87	7
Total	9.58	----------	1,970.0	11,000	78
Total for average acre	20.86	----------	2,305.0	12,485	90

[1] No deduction has been made for tree mortality or losses from wood rotting fungi, etc. Net growth per acre may be as great as 85 percent of amount shown or insect and other losses may entirely wipe out the current growth in mature stands.

Studies of the growth of ponderosa pine by Dr. Walter N. Meyer, of the Pacific Northwest Forest Experiment Station (*20*), have shown that where sufficient growing stock is preserved after each cut the rate of growth is fairly satisfactory. Where a stocking of 2,000 cubic feet per acre is preserved 690 cubic feet is added to the volume in the next 30 years. Where a growing stock of only 200 cubic feet is preserved only 220 cubic feet of growth is obtained in that period. These results are from all-aged stands.

In terms of saw timber 11.6 inches or more in diameter, a stocking of 10,000 board feet produces 4,000 board feet of added growth in 30 years, whereas a stocking of 1,000 board feet produces only 1,300 board feet in the same time. Owing to greater risk of insect attack on older trees it may be undesirable to leave fully stocked stands after the first cutting in virgin timber. If understocked stands are left the growing stock should be built up with younger trees during further management operations.

It should be noted that while Meyer shows only 15 board feet per year mortality loss in selectively cut stands, he cites Bureau of Entomology studies made under the direction of F. P. Keen in virgin stands in southern Oregon and northern California showing insect losses amounting to from 103 to 1,082 board feet per acre per year in 1927, the year of heaviest recorded loss. On the 17,400 acres covered by these studies the loss averaged 417 board feet per acre. By 1930 this had shrunk to 226 board feet per acre. It is possible, but has not been definitely determined, that insect injury would be reduced by passing over all the stands as rapidly as possible with a light cutting in order to eliminate the most susceptible trees.

FUTURE OWNERSHIP DISTRIBUTION OF THE PACIFIC COAST FORESTS

Competent local observers believe private ownership of forests on the Pacific coast will shrink within the next generation to 8 million acres, or less than one fourth the present figure. This appears to be a matter on which a dependable prediction cannot be made. If there is not a sufficient body of enterprisers to take advantage of the opportunities for operating these highly productive forests continuously, in the course of time the areas will automatically revert to some type of public ownership. This will take place through the tax-delinquency route if not otherwise. It is intolerable that these last magnificient forest areas should become waste lands stripped of their stands and degraded by ruthless cutting and fire. This would be too great a price for the preservation of individual initiative. It would in fact constitute the irrevocable extinction of individual initiative as applying to this resource.

On the other hand it has been abundantly proved that public ownership is capable of permanently preserving the productivity of these forests. If private ownership cannot preserve their productivity, it is possible to perpetuate the opportunity for individual initiative in the manifold activities connected with harvesting forest raw materials on public lands and with the diversified manufacturing enterprises using such materials.

In order to bring to an end the numerous losses incident to the logging methods of the past 20 years these practices should be stopped forthwith, by whatever means necessary. Various methods of stopping them are discussed elsewhere in this report. Private, State, and Federal agencies concerned should then enter into a thoroughgoing cooperative study of the whole region, unit by unit. The study should lead to conclusions as to which of the several agencies, private, State, and Federal, should handle each productive unit. No agency should undertake to handle any unit unless it is prepared to keep the unit in permanent producing condition and thus can accept the full responsibility that from now on should be irrevocably associated with the privilege of ownership of our remaining natural resources.

FORESTS OF THE ROCKY MOUNTAIN REGION

(Idaho, Montana, Wyoming, South Dakota, Nevada, New Mexico, Utah, Colorado, and Arizona)

STATUS AND MANAGEMENT OF PRIVATE FORESTS

The privately owned forest area in the Rocky Mountain region is estimated at 12,479,000 acres, of which 1,880,000 is poor to nonrestocking, 1,556,000 fair to satisfactory restocking, 2,711,000 cordwood, and 6,332,000 saw timber. (See table 1.) Roughly, one half the privately owned forest land is occupied by saw timber and bears an estimated stand of approximately 51 billion board feet. Farm woodlands total 1,456,000 acres. Of the remaining 11,023,000 acres in private ownership a large part, undoubtedly, is held for other purposes than utilization of the commercial timber. This is an important grazing region, and most of the forest types yield considerable crops of forage.

The Rocky Mountain region as a whole has an interior continental climate with low precipitation. For this reason the forest growth is too slow, in the opinion of many authorities, to make permanent management attractive to private owners. This depends to a considerable extent on how successfully private owners coordinate the use of range and other resources. In a few localities, such as northern Idaho and portions of western Montana, topographic conditions cause precipitation adequate for rapid forest growth. Unfortunately the very valuable western white pine, which is the chief source of value in this section of adequate rainfall is threatened by the white pine blister rust. It is estimated that an immediate investment of about $2.50 per acre is necessary to protect the pine from injury from this source. Many private owners are unable to make this expenditure. Fire protection, also, is a source of heavy expense. If these expenses can be met permanent private management for commercial forest production is feasible in these localities. The returns forest owners will realize from these and other areas can in most cases be greatly increased by prolonging the cut of the existing stands, as will be discussed later.

Because of the climatic and other conditions just mentioned, maintenance of forest cover and continued forest production in the Rocky Mountain region depend very largely upon public ownership and management of the bulk of the forest resource. In most localities there is a marked tendency toward returning to public ownership of one form or another the scant area now in private ownership. Nevertheless it is desirable that private ownership continue, where it is feasible.

EXTENT TO WHICH PRIVATE OPERATORS ARE PRACTICING FORESTRY

The measure of effectiveness in fire protection necessary to continued forest productivity has been reached on very few private forest properties in this region. Until the period of severe curtailment of lumber production, starting in 1930, fire-protective efforts were constantly increasing. Ten large companies and a much greater number of small owners in the region are reported to the United States Forest Service as having 5,618,489 acres under organized protection in 1931. The reports, it is believed, do not cover the entire private protective effort. The methods used include cooperation with Federal and State forestry organizations, cooperative action among owners through associations, and, to a lesser extent, organization for protection of individual properties.

Reports received show that six operators, owning 890,334 acres, are practicing selective cutting, planting, and other measures (in addition to fire protection) calculated to prolong forest productivity. The practice of selective cutting is based generally on the knowledge that cutting the smaller trees leads to current losses. It is probable that owners of a considerable area not included in these reports, largely in small holdings, are cutting selectively. No cases of definite committal to sustained-yield practice are reported in the Rocky Mountain region. The measures taken on certain properties in north Idaho are adequate preliminary steps in this direction providing sustained yield is decided on without too much delay and mill capacity is adjusted to the producing capacity of the forests.

Aside from fire-protective effort, which is of great importance and in the northern section is very costly, it is readily observable that private forestry effort is limited to a very small proportion of the areas in private ownership in this region.

PRODUCTION AND CONSUMPTION OF FOREST PRODUCTS

Because population is rather sparse in the Rocky Mountain region, the regional market for forest products does not require large volumes. The United States Forest Products Census of 1928 yielded the following statistics on lumber production and consumption in the region:

Table 10.—*Production and consumption of lumber in the Rocky Mountain region*

State	Production [1]	Consumption [2]
	M board feet	*M board feet*
Idaho	977,468	211,698
Montana	387,879	266,641
Wyoming	24,402	134,669
South Dakota	53,967	174,378
Utah	7,623	128,066
Colorado	72,257	228,112
Arizona	158,047	84,523
New Mexico	162,030	110,034
Rocky Mountain region	1,843,673	1,338,121

[1] Data from Forest Products, 1928: Lumber, lath, and shingles. Bureau of the Census, 1930.

[2] Figures based on compiled data in the files of the Forest Service.

This shows production of only 505,552 thousand board feet in excess of consumption. Much lumber is shipped in from the Pacific coast region and some from the southern pine region, while lumber of other species is shipped out. In the long run the prospects are that production will not exceed consumption. In addition to lumber consumption, large quantities of timbers, poles, and posts are required by industries including mines, public utilities, railroads, grazing, and agriculture. In many localities wood is used as fuel. This creates a possibility of balanced use of forest raw material within the region, whereby large-sized trees are used for saw logs while the tops of such trees and smaller trees from thinnings, of small-size species, and from areas where timber does not develop to saw-log size are available for the uses which require only small sizes.

RELATION OF FOREST USE TO REGIONAL ECONOMIC CONDITIONS

Current economic history has brought sharply to our attention the great advantages held by localities having diversified industries. Such localities, being able to carry on local exchanges of their varied products, suffer far less from dislocation of prices and of other economic factors than do single-industry regions dependent on exchanging products with distant regions or in foreign trade. The question of diversification has special significance in a region subject, as is the

Rocky Mountain region, to high transportation costs on both its imports and its exports.

Thus it is of first-rate importance to the region, both as producer and as consumer of forest products, that the productivity of its forests and the vitality of its forest industries be maintained. The question of the type of ownership necessary to give stability to forest productivity and use should, therefore, be settled as speedily as possible. Permanent division between public and private ownership cannot well be made until the risks that surround private forest ownership are definitely limited.

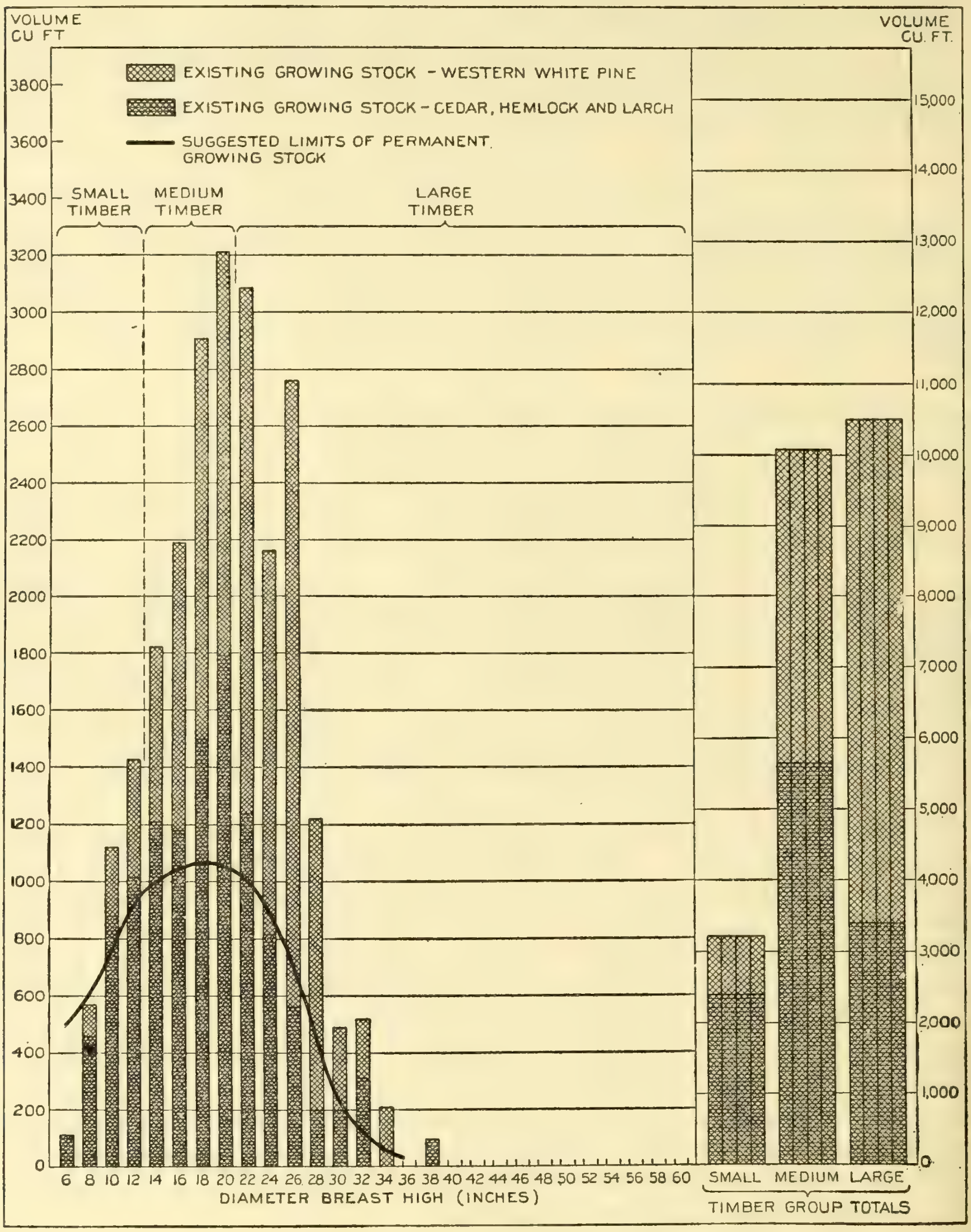

FIGURE 10.—Distribution of cubic volume by diameter classes on heavily stocked acre, site 1, western white pine with cedar, hemlock, and larch, Kaniksu National Forest, Idaho. Future management aims at converting stand more largely to white pine without eliminating subordinate species entirely. In the gradual adjustment of the stand to the limits suggested, inferior species should share cuttings with the white pine.

CONDITION OF TYPICAL TIMBER STANDS AND MANAGEMENT METHODS SUGGESTED

The private-forestry possibilities of the region fall almost entirely within two forest types—the western white pine mixed with other conifers, occurring principally in northern Idaho, western Montana, and northeastern Washington; and the ponderosa pine type, which is distributed in numerous localities throughout the region.

WESTERN WHITE PINE

No data are available for an average example of the western white pine type. The stand shown in figure 10 and table 11 is unusually heavy, having 12,332 cubic feet of western white pine and 11,608 cubic feet of western red cedar, western hemlock, and western larch, or 23,940 cubic feet in all (*21*). It is a very interesting example of an association of species having complementary characteristics such as the shallow rooting and shade endurance of hemlock and cedar and the somewhat deeper rooting habit and need for full light of the pine and larch. On areas occupied by such associations the fullest possible use is made of the site, and vegetative activity is confined almost entirely to the growth of the tree species. For these reasons the stands pile up a very heavy wood volume per acre; the volume in this case exceeds that in most of the examples given for the heavy Pacific Coast forests. If the forest is broken up into the selective form it is necessary to provide for a permanently heavy stocking. Unless stocking is maintained, the productivity of the site will be diverted to shrubs and to seedlings and saplings of the inferior species.

TABLE 11.—*Number of trees and volume, in 140-year-old heavily stocked western white pine stand, in Kaniksu National Forest, Idaho*

Tree diameters at breast height	Trees per average acre					Gross cubic volume [1]					Gross saw-timber volume [1]				
	White pine	Western red cedar	Western hemlock	Western larch	Total	White pine	Western red cedar	Western hemlock	Western larch	Total	White pine	Western red cedar	Western hemlock	Western larch	Total
Small timber:	*No.*	*No.*	*No.*	*No.*	*No.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Ft. b.m.*	*Ft. b.m.*	*Ft. b.m.*	*Ft. b.m.*	*Ft. b.m.*
6 inches	--------	17.7	1.3	--------	19.0	--------	106.20	5.20	--------	111.40	--------	327	16	--------	343
8 inches	8.0	36.3	2.7	--------	47.0	112.00	435.60	25.65	--------	573.25	386	1,502	88	--------	1,976
10 inches	9.7	37.7	3.7	1.0	52.1	237.65	791.70	69.56	21.00	1,119.91	914	3,045	268	81	4,308
12 inches	11.0	25.0	1.7	4.3	42.0	415.80	820.00	52.36	141.04	1,429.20	2,009	3,961	253	681	6,904
Total	28.7	116.7	9.4	5.3	160.1	765.45	2,153.50	152.77	162.04	3,233.76	3,309	8,835	625	762	13,531
Medium timber:															
14 inches	11.3	15.0	2.7	8.7	37.7	611.33	687.00	126.63	398.46	1,823.42	3,396	3,817	704	2,214	10,131
16 inches	13.7	11.3	.7	7.0	32.7	1,011.06	697.21	46.55	431.90	2,186.72	5,947	4,101	274	2,541	12,863
18 inches	14.7	7.0	2.0	9.7	33.4	1,396.50	556.50	183.00	771.15	2,907.15	8,728	3,478	1,144	4,820	18,170
20 inches	12.0	7.7	1.0	9.3	30.0	1,422.00	756.91	120.80	914.19	3,213.90	8,888	4,731	755	5,714	20,088
Total	51.7	41.0	6.4	34.7	133.8	4,440.89	2,697.62	476.98	2,515.70	10,131.19	26,959	16,127	2,877	15,289	61,252
Large timber:															
22 inches	12.7	2.7	1.3	6.0	22.7	1,846.58	323.46	198.51	718.80	3,087.35	11,913	2,087	1,281	4,637	19,918
24 inches	7.7	.7	1.0	3.7	13.1	1,345.19	99.68	190.40	526.88	2,162.15	8,850	656	1,253	3,466	14,225
26 inches	10.7	1.0	1.0	1.0	13.7	2,196.71	167.30	233.40	167.30	2,764.71	14,548	1,108	1,546	1,108	18,310
28 inches	4.3	.3	.3	.3	5.2	1,018.24	57.72	82.92	57.72	1,216.60	6,788	385	553	385	8,111
30 inches	1.0	1.0	--------	--------	2.0	270.30	217.20	--------	--------	487.50	1,802	1,448	--------	--------	3,250
32 inches	.7	1.3	--------	--------	2.0	212.80	313.30	--------	--------	526.10	1,419	2,089	--------	--------	3,508
34 inches	.7	--------	--------	--------	.7	236.60	--------	--------	--------	236.60	1,577	--------	--------	--------	1,577
36 inches	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
38 inches	--------	.3	--------	--------	.3	--------	94.98	--------	--------	94.98	--------	633	--------	--------	633
Total	37.8	7.3	3.6	11.0	59.7	7,126.42	1,273.64	705.23	1,470.70	10,575.99	46,897	8,406	4,633	9,596	69,532
Total for average acre	118.2	165.0	19.4	51.0	353.6	12,332.76	6,124.76	1,334.98	4,148.44	23,940.94	77,165	33,368	8,135	25,647	144,315

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[1] No defect deducted.

In view of the silvicultural desirability of this mixture it is unfortunate that some of the species are of inferior value. This is especially true of the hemlock and white fir, which are not only intrinsically of low value in the region but very defective as well. The growth of the subordinate species, however, is probably in considerable measure a surplus over what can be produced by pine alone. It seems necessary, therefore, to perpetuate the mixture, striving to increase the pine with cedar as a preferred understory.

By what method this type should be managed is a somewhat controversial question. The selection system is here suggested. Although the type is very productive there are a number of difficult management problems to be solved. The growing stock cannot be brought by one cutting to the volume suggested in figure 10 as permanently desirable. A series of cuttings, preferably at intervals of not more than 10 years, is indicated, though present practice contemplates intervals of 20 years or more. Where permanent main transportation systems can be maintained combined with the prevailing combinations of tractor and horselogging no very serious additional costs are created by short cutting cycles. The utilized yield is almost invariably increased through cutting, at each return to the area, trees that would die and decay in the interval of a long cutting cycle. If white pine is to be maintained in the stand it will be necessary to make small openings at each cutting so that pine can seed in. The white pine areas of the Rocky Mountain region lack balance in their wood-using industries and it is therefore difficult to dispose of the inferior material. Owing to this difficulty, in the early cuttings the openings to encourage pine reproduction must necessarily be located where pine makes up most of the stand. It is reasonable to expect the market for inferior species to improve with time. Defective trees constitute an additional silvicultural problem. Where they occur in groups to be cut they should be felled and destroyed with the slash. When he new stand on cut-over spots has developed to seed-bearing age the emainder of the old stand can be removed more freely than in he early cuttings, if in the meanwhile a market has developed for he remaining subordinate species.

Owing to the heavy costs of blister-rust control, effective fire conrol, the elimination of defective inferior species, etc., forestry in the estern white pine type is somewhat expensive. The high value of hite pine together with its high rate of productivity justify these osts, at least on the better sites. Intensive methods are indicated as he cheapest means of production.

PONDEROSA PINE

Conditions in the ponderosa pine type are somewhat as shown in gure 9 for eastern Oregon. Large areas where rainfall is especially eficient have much smaller stands per acre than those shown and ery slow rates of growth. Successful management of these areas epends on keeping capitalization low, utilizing conservatively both te grazing and the timber returns, and through a policy of very ht cuttings insuring natural regeneration and development of trees t merchantable size with very little direct money outlay.

DESIRABLE CHANGES IN MANAGEMENT POLICY

As in other regions, the policy of hasty liquidation is causing heavy losses in lumbering operations. In the application of this policy there has been much overbuilding of manufactuirng plants, so that further heavy losses will undoubtedly result from inability to recover plant investments through operation. The full extent of such losses does not appear until the end of the operating period. These losses may be much reduced through prolonging the timber cut and consequently the useful life of the dependent manufacturing plants.

Intensive logging and milling studies have shown that in the Rocky Mountain region, as in others, a large proportion of the trees cut in current practice are logged and milled at a loss. Figure 11 (*22*) shows that in a typical ponderosa pine operation in 1931, all trees less than 20 inches in diameter cost more to log and manufacture than sales of lumber returned. In practice it is unwise to cut under 24 inches except to remove smaller trees undesirable for the future stand. If that limit is observed the stand remaining will contain sufficient growing stock to add a considerable volume before the next cut, 15 to 30 years later. Deferred cutting of the trees that can yield no profit now would result in more orderly delivery of the timber from these forests to the market, give more time for local consumers to absorb a large portion (especially of the cheaper grades), allow the national market to be cleared of the surpluses now arising from liquidating privately owned forests, and permit the residual stands to gain in volume and quality and thus in stumpage price. It is readily understandable that in some cases financial and other factors place considerable difficulties in the way of the adoption of these changes in policy.

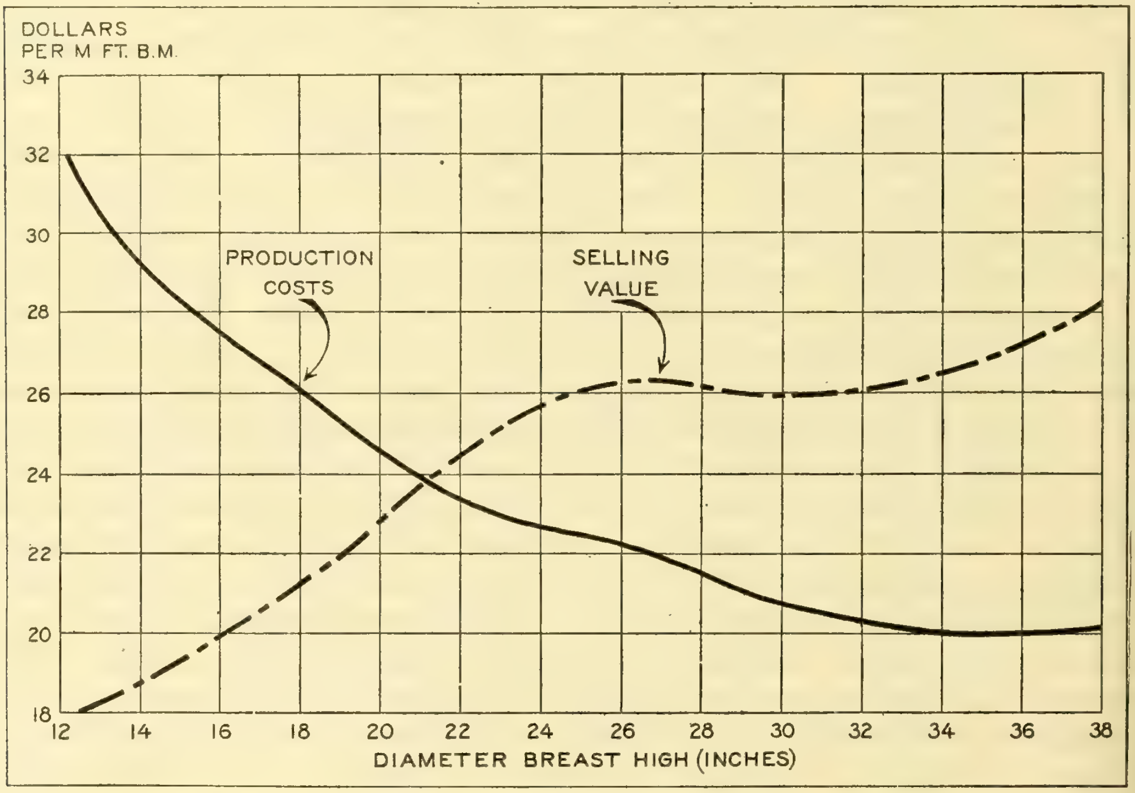


FIGURE 11.—Production costs versus selling value of Ponderosa pine, 1931.

FORESTS OF THE SOUTH

(Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Texas)

PRESENT CONDITIONS AND MANAGEMENT POLICIES

The estimated area of privately owned forest land in the South is 187,264,000 acres, of which 57,866,000 acres is in farm woodlands. The forest area in public ownership is small. Commercially valuable species of pines are found throughout the South, making it the most extensive pine region in the world. In river bottom lands and swamps and at the higher altitudes occur considerable areas of hardwoods. Most of the land in the region is level or only gently sloping, which makes extraction of timber from the forests very simple.

Cutting has been carried on entirely without regulation, and as a rule with little regard to the future effect on the forest. As might have been expected, under this practice the forest productivity has suffered severely. According to the best estimates (see table 1), 43,229,000 acres are in poor to nonrestocking condition and 36,802,000 acres contain a fair amount of young growth but lack larger growing stock. Of the areas having immediately effective growing stock, 52,013,000 acres bear timber of cordwood size and only 55,220,000 bear saw timber, much of which is second growth. On the saw-timber areas the growing stock is very seriously depleted.

As in other regions, three grades of forest-management effort are considered.

1. Fire protection: Elsewhere in this report detailed data on fire protection are presented. In proportion to the areas involved, fire-protective effort is less widespread in the South than in other regions. Undoubtedly the southern pines, on account of greater resistance to injury from fire, are more productive in the absence of fire protection than most commercial species of other regions. They vary among themselves in this respect, and some types suffer from fire more than others. Hardwoods, whether mixed with the pines or in pure stands, are severely damaged by fire.

The areas of 1,000 acres or more reported to be under private protection in this region are as follows: Virginia, North Carolina, and South Carolina, 1,441,748 acres; remainder of the region, 7,760,000 acres; total, 9,201,748 acres. In addition there are large areas of farm woodlands which because of their isolated situation or the efforts of the owners are protected from fires. Public efforts are extending protection to much larger areas.

2. Conservative cutting, planting, leaving seed trees, and other practical measures for improving production, without definite plans or sustained yield, are reported to be practiced on the following areas: Virginia, North Carolina, and South Carolina, 662,500 acres; remainder of the region, 2,092,500 acres; total, 2,755,000 acres.

3. Permanent forest land management and organized plans for sus-ained yield (by a somewhat liberal construction) may be said to be n effect on the following aggregate areas: Virginia, North Carolina, nd South Carolina, 5,000 acres; remainder of the region, 1,349,000 cres; total, 1,354,000 acres. Large additional acreages are in con-ition to warrant putting them on a definite sustained-yield basis. o do this would necessitate systematizing the operations already

more or less commonly carried on to improve future production and placing a close control on expenditure, income, and maintenance of capital values.

The Southern Forest Experiment Station estimates (*23*) that the following areas in the several types should be under intensive management within 20 years:

	Acres
Longleaf-slash-pine type	6, 340, 000
Shortleaf-loblolly-hardwood type	9, 715, 000
Riverbottom hardwood and cypress type	2, 710, 000
Total	18, 765, 000

The sustained yield area noted above is included in these areas.

PRODUCTION AND CONSUMPTION OF FOREST PRODUCTS

Settlement of the South occurred early in the history of the Nation. In consequence of the fact that other regions of the United States were well supplied with forests until nearly the end of the nineteenth century, a large timber industry beyond the needs of the region and of some coastwise and export trade did not develop until about 1880. Annual production then increased rapidly to a maximum in 1909 of nearly 20 billion board feet. The region now supplies more than one third of the Nation's softwood lumber, and more than one half of its hardwoods. The relation between production and consumption is shown for each State and for the region as a whole in table 12.

TABLE 12.—*Lumber production and consumption in the South in 1928*

[In thousand board feet]

State	Production [1]			Consumption [2]
	Softwood	Hardwood	Total	
Virginia	352, 049	195, 657	547, 706	451, 685
North Carolina	787, 616	233, 277	1, 020, 893	620, 130
South Carolina	660, 025	161, 875	821, 900	126, 755
Georgia	888, 437	151, 038	1, 039, 475	364, 740
Florida	933, 514	61, 558	995, 072	416, 106
Alabama	1, 731, 783	248, 299	1, 980, 082	526, 092
Mississippi	2, 085, 097	439, 222	2, 524, 319	436, 316
Louisiana	1, 550, 414	728, 008	2, 278, 422	707, 880
Arkansas	659, 149	470, 582	1, 129, 731	400, 725
Oklahoma	174, 957	18, 836	193, 793	456, 288
Texas	1, 217, 361	229, 325	1, 446, 686	1, 588, 051
Total	11, 040, 402	2, 937, 677	13, 978, 079	6, 094, 768

[1] Data from Forest Products, 1928: Lumber, lath, and shingles. Bureau of the Census, 1930.
[2] Figures based on compiled data in the files of the Forest Service.

The South's surplus in 1928 of 7,883,311,000 board feet over its own consumption slightly exceeded that of the Pacific coast region.

Although lumber is the outstanding forest product of the South, many others are of great importance. The longleaf- and slash-pine belt is the sole source of naval stores in the United States and produces greater quantities of naval stores than any other region in the world. In recent years a large pulp and paper industry has developed. Poles, posts, and piling are produced on a considerable scale for local use and for shipment to other regions.

As against the surplus over regional requirements of nearly 8 billion feet of lumber and large volumes of other forest products should be considered the requirements of a great belt of States stretching from the prairies of the upper Mississippi Valley through the Lake and Central States to the coast of New England and the Middle Atlantic States. The forests of these States lack nearly 15 billion feet of producing sufficient lumber for local use, not to mention other forest-products requirements. Moreover, the forests of these States now consist mostly of hardwoods, while the South produces great quantities of conifers. Numerous railroad lines, together with water routes, provide adequate transportation between the regions.

This situation has been so favorable for the southern forest industries that production has gone on as a matter of course without much thought of the continuity of the supply. The certain evidences of decline in production justify a change in policy by all agencies concerned. The need is for organized forest management, which in comparison with chance or hit-and-miss methods produces just as superior results as organized effort does in other fields of business.

FINANCIAL ASPECTS OF FOREST USE

Because of its vast land area, the South has a potential productivity for its characteristic agricultural crops that far exceeds market possibilities. Diversification of industry into other fields is thus peculiarly necessary. The wide distribution of forest stands has made the forest industries the outstanding supplement of agricultural activity. Forest industries have supplied employment, and an oulet for timber from farm woodlands, the loss of which would be calamitous to the region. The region's naval-stores industry, its recently developed pulp industry, and its outlets for posts, poles, and piling make for balance in demand for forest raw material; it cannot be said, however, that the possibilities of such balance have been worked out with much refinement. The naval-stores industry is destroying timber unnecessarily in its operations. The pulp industry, though using considerable mill and forest waste, is responsible for the premature cutting of considerable areas of young growth, destroying the stands as they enter the period of greatest increase in value. At present the pulp industry is obtaining material at very low cost, the forest owner receiving practically no return for the use of his property. If pulpwood material were taken in thinnings the landowner, though receiving only labor costs or slightly more, as at present, would be compensated by the production of higher-priced material to be cut later. Under this procedure the pulp industry would perpetuate its command of low-cost raw material.

Information accumulated by the Forest Taxation Inquiry indicates that the value of the forest land and stumpage in the South totals about $1,595,477,000 (*24*). Accurate data on mill and logging investments are not available. Much of the cut is now being made by small mills. In recent years investments in larger mills have declined in value. The future of both types of investments depends directly on the foresight and skill with which forest owners, managers, and technicians handle the forests. Beyond these factors public attitudes are of great importance in establishing a favorable setting for forward-ooking policies. The forest as a resource is so exposed to public action through taxation, through the uncontrolled use of fire, and in other ways that the management efforts of the forest owner are likely to be in vain when the public attitude is adverse or even indifferent.

In the South the huge forest area and the ease of forest regeneration create a situation in which cutting alone would create no immediate danger of an excessively low rate of yield. Owing to the largely unrestricted use of fire, however, the loss of productivity is considerable. Soil conditions over large areas are such as to permit alternative use for forestry or agriculutre. Much land formerly used for agriculture has been taken over by timber. A survey of Union Parish, La. (*25*), showed that 18 percent of the forests were old-field stands. In the future there will probably be further changes from agricultural to forest use and from forest to agricultural use. It is conceivable that on soils where the fertility has been impaired forest crops will be grown for the definite purpose of restoring fertility needed for future agricultural use.

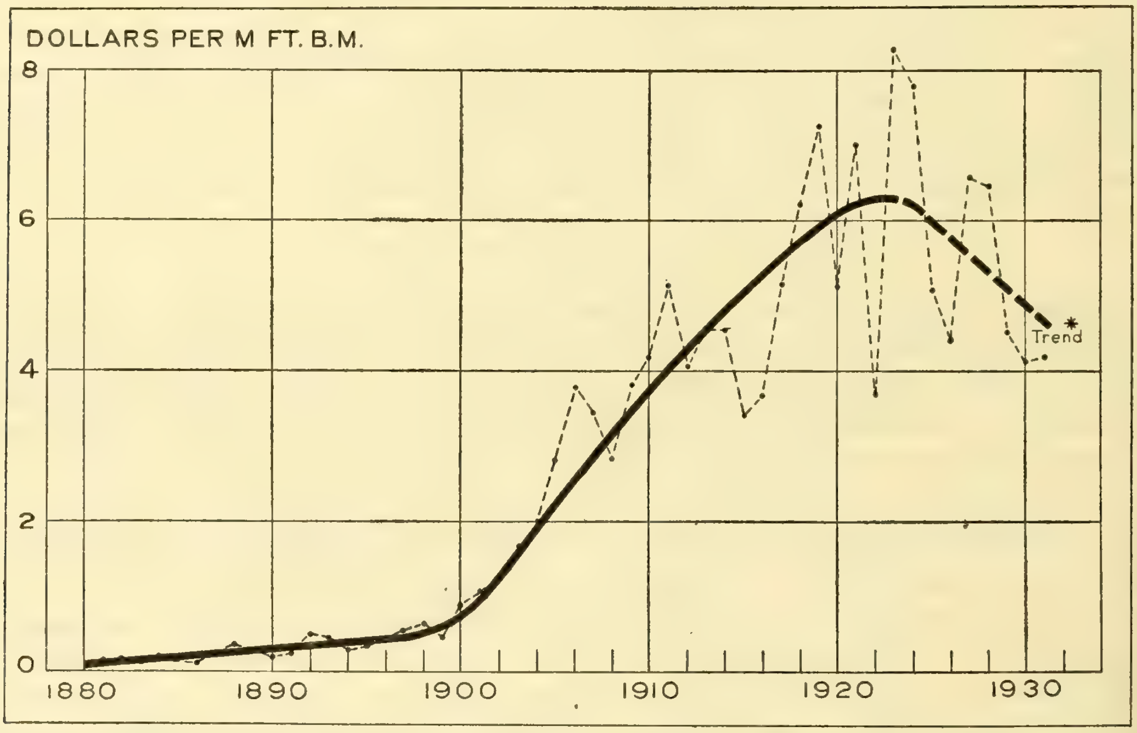


FIGURE 12.—Stumpage price of southern yellow pine, Louisiana, Texas, Alabama, Mississippi, Florida-Georgia, 1880–1931 (compiled by U.S. Forest Service from sales of 86 billion feet of privately owned timber). The broken line 1923–31 represents the trend during the deflation period subsequent to the World War. The inclusion of data for future years may materially change this portion of the general trend. In fact the slight increase of 1931 over 1930 may indicate that the upturn has commenced. Includes since 1900 sales of approximately 3 billion feet of second-growth pine.

STUMPAGE PRICES (*26*)

Based on averages for all the species and grades of southern pine that were being cut commercially in the years since 1880, figure 12 shows graphically the price changes since 1880. It is based on answers to questionnaires of the United States Forest Service since 1921 and on such data as were available prior to that date.

It is interesting to observe the parallel course of price movements in pine stumpage and cotton, two great southern staples. Figure 13 shows by price indexes based on prices of the year 1926 as 100 that since 1929 second-growth pine stumpage has held up in prices better than cotton.

STANDS AND INCREMENTS IN A TYPICAL COUNTY

Data obtained from surveys of counties distributed through the South show that in general the lumber cut must be expected to decline in the next few years. The following statement of the Southern Forest Experiment Station, with table 13, shows the present status in a county where conditions are better than average (*25*):

A county-wide study in the shortleaf- loblolly-pine hardwoods in northern Louisiana yielded the data set out in the following tabulation of second-growth

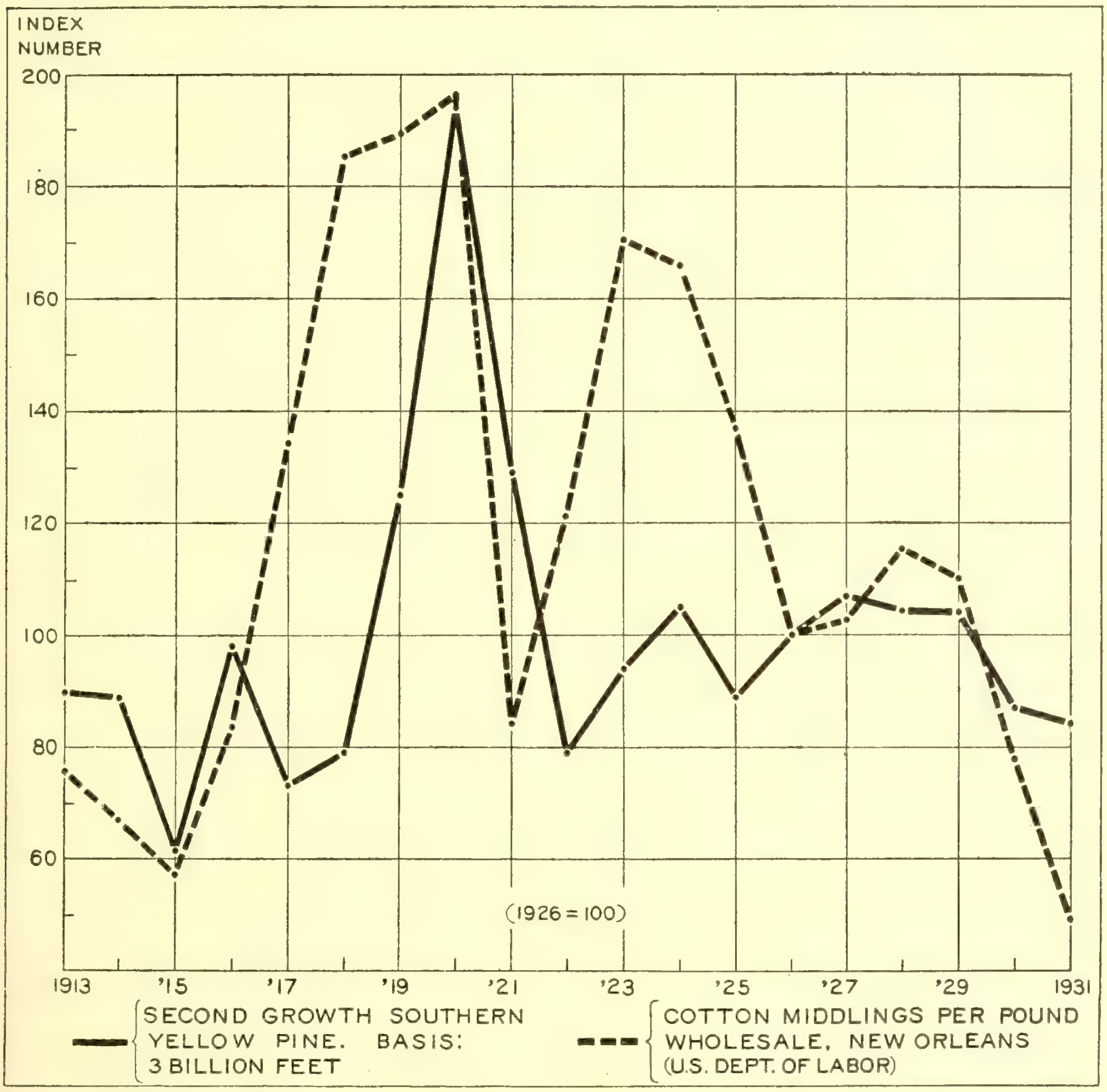


Figure 13.—Comparison of price indexes of cotton and second-growth southern yellow pine stumpage.

tands and current annual increment. These data show actual conditions as hey exist on certain areas of better forest lands, except that the percentage of ld-field stands, and hence the rate of growth, in this county is considerably above he average. In the average county the percentage of old-field stands probably oes not exceed 5. The better stands of this county show conditions favorable or private commercial forestry operations. The trees making up each old-field tand are fairly even aged, but the stands vary widely in age. However, a merhantable old-field stand with trees practically even aged has a considerable range f diameter classes. Most of the second-growth stands have been cut two or ore times, and the trees vary considerably as to age and usually have a good istribution of diameters.

TABLE 13.—*Timber stands and current annual increments, by classes of stands, in Union Parish, La.*[1]

Class of stand	Area	Proportion of forest area in county	Pine volume per acre [2]		Current annual increment of pine per acre [2]	
			Trees 9 inches or more in diameter breast high	Trees 13 inches or more in diameter breast high	Trees 9 inches or more in diameter breast high	Trees 13 inches or more in diameter breast high
Merchantable second-growth pine:	*Acres*	*Percent*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
Well-stocked	28, 900	8	10, 468	5, 618	607	569
Poorly-stocked	83, 200	23	2, 472	1, 207	216	201
Old-field	65, 100	18	6, 528	3, 121	626	425
Pine-hardwood bottom	25, 300	7	1, 904	1, 246	186	186
Cut-over unmerchantable pine:						
Restocking	61, 500	17	275	49	55	18
Nonrestocking	25, 300	7	323	23	58	19
Denuded	14, 500	4	0	0	0	0
Hardwood bottom	57, 800	16	0	0	0	0
Total	361, 600	100				

[1] Data from the Southern Forest Experiment Station.
[2] Volumes by International one-eighth inch log rule.

The excellent growth in well-stocked stands is worthy of special attention. It is very plain that the owner of poorly stocked stands has to pay taxes and the expenses of fire protection and administration on more than 2 acres to obtain production equal to that of 1 acre of well-stocked stands.

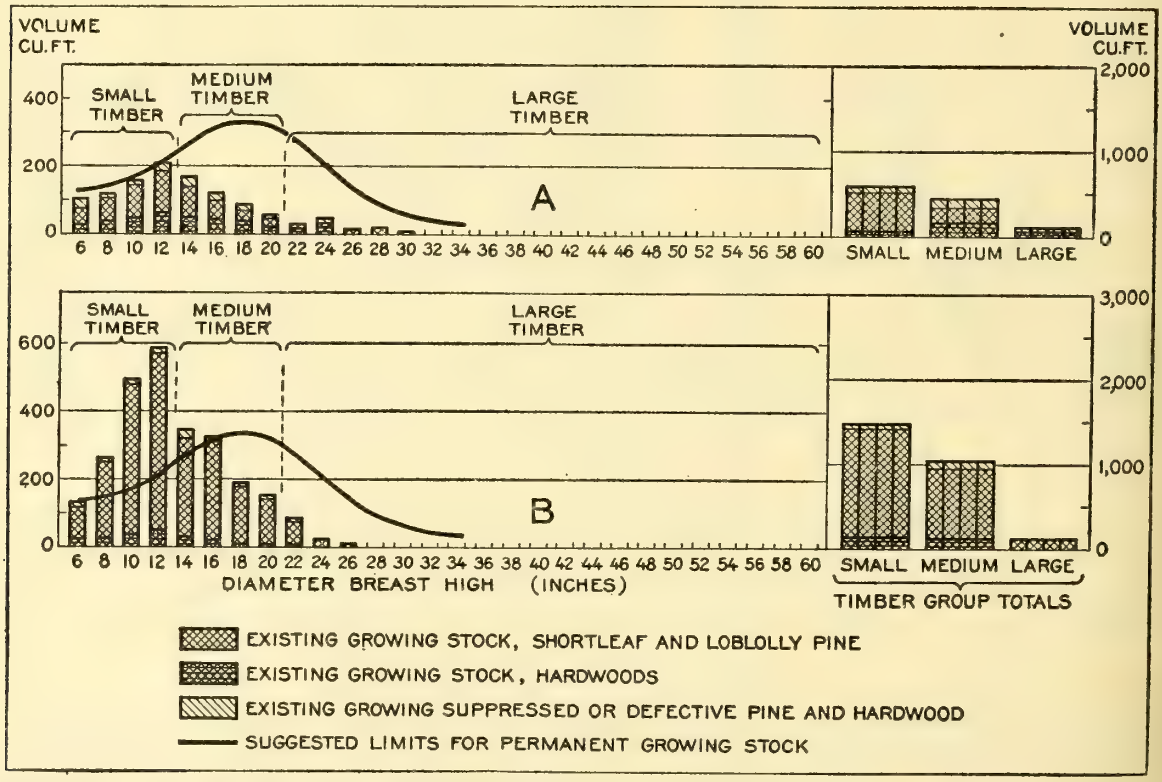


FIGURE 14.—Distribution of cubic volume by diameter classes on average acre of shortleaf-loblolly pine and hardwood stands. A, Poorly stocked stands said to represent average conditions on 7,000,000 acres in southern Arkansas, northern Louisiana, and eastern Texas; B, well-stocked stands average from an inventory of 28,900 acres said to be representative of 600,000 acres in southern Arkansas, northern Louisiana, and eastern Texas. There are sufficient trees in the stand but it should be managed toward a larger proportion of larger size classes.

CONDITION OF TYPICAL STANDS, AND MEASURES THAT WILL BUILD UP THEIR PRODUCTIVITY

Investigations of timber growth, surveys of forest conditions in individual counties, and the general forest survey now under way under the direction of the Southern Forest Experiment Station are beginning to yield definite detailed information as to the condition of individual stands. Four cases will be cited.

(1) *Average-stocked shortleaf and loblolly pine with hardwoods.*—It is believed that the problem of building up the stands is simpler with shortleaf and loblolly pine than with longleaf pine, which will be discussed later. It is probable, also, that the total volume per acre of selection forests of these species would normally exceed that of longleaf. Figure 14, diagram A, and table 14 show conditions in certain stands of this type in southern Arkansas. The acre averages are based on an inventory of 345,000 acres of average-stocked stands in the shortleaf-loblolly-hardwood type and are estimated (*25*) to be typical of conditions on 7 million acres of this type. This area comprises some of the most productive forests of this type and cannot be taken as typical of larger areas of the type.

TABLE 14.—*Number of trees, volume and growth average stocked shortleaf and loblolly pine with hardwood stands in southern Arkansas*

Tree diameters at breast height	Trees per average acre				Time required to grow to next diameter class [1]			Cubic volume [1]				Saw timber volume [1]				Average annual growth of saw timber [2]		
	Short-leaf	Lob-lolly	Hard-woods	Defective all species	Short-leaf	Lob-lolly	Hard-woods	Short-leaf	Lob-lolly	Hard-woods	Total	Short-leaf	Lob-lolly	Hard-woods	Total	Short-leaf	Lob-lolly	Total
Young stock:	*Number*	*Number*	*Number*	*Number*	*Years*	*Years*	*Years*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Ft.b.m.*	*Ft.b.m.*	*Ft.b.m.*	*Ft.b.m.*	*Ft.b.m.*	*Ft.b.m.*	*Ft.b.m.*
2 inches	3.48	8.31	20.58	6.72	13	10	20	0.35	0.83	2.57	3.75							
4 inches	4.51	10.35	12.59	7.23	12	10	20	4.92	9.32	10.95	25.19							
Total	7.99	18.66	33.17	13.95				5.27	10.15	13.52	28.94							
Small timber:																		
6 inches	4.77	8.24	11.78	4.16	12	9	15	17.84	28.68	28.74	75.26	52	124		176	10.5	16.8	27.3
8 inches	3.94	5.02	6.96	1.76	12	9	14	33.25	39.56	38.28	111.09	118	136	42	296	17.8	21.0	38.8
10 inches	3.18	3.97	4.28	1.07	11	8	14	48.46	55.26	45.45	149.17	235	238	180	653	21.0	32.5	53.5
12 inches	2.02	3.19	3.63	1.23	11	8	14	48.48	75.28	64.98	188.74	269	364	323	956	13.7	32.5	46.2
Total	13.91	20.42	26.65	8.22				148.03	198.78	177.45	524.26	674	862	545	2,081	63.0	102.8	165.8
Medium timber:																		
14 inches	.85	1.51	1.95	1.01	11	8	14	30.26	52.85	53.41	136.52	177	290	287	754	6.2	20.0	26.2
16 inches	.27	.84	1.23	.58	11	7	14	13.04	40.74	47.90	101.68	77	234	271	582	2.1	14.7	16.8
18 inches	.12	.37	.78	.46	12	7	14	7.72	23.68	41.14	72.54	46	144	242	432	1.0	6.3	7.3
20 inches	.04	.23	.42	.17	12	7	14	3.26	18.31	28.87	50.44	20	117	178	315		4.2	4.2
Total	1.28	2.95	4.38	2.22				54.28	135.58	171.32	361.18	320	785	978	2,083	9.3	45.2	54.5
Large timber:																		
22 inches	.01	.10	.12	.15	12	6	15	.99	9.70	10.47	21.16	6	64	68	138		2.1	2.1
24 inches		.05	.26	.15		6	15		5.75	28.92	34.67		39	196	235		1.0	1.0
26 inches		.02	.02	.02		6	15		2.65	2.80	5.45		18	20	38			
28 inches			.06	.02			15			10.44	10.44			79	79			
30 inches			.02	.01			16			4.20	4.20			34	34			
Total	.01	.17	.48	.35				.99	18.10	56.83	75.92	6	121	397	524		3.1	3.1
Total for average acre	23.19	42.20	64.68	24.74				208.57	362.61	419.12	990.30	1,000	1,768	1,920	4,688	72.3	151.1	223.4

[1] Defective trees not included.

[2] Defective trees and hardwood not included. Hardwood is growing at rate of about 80 board feet per acre per annum but defects caused chiefly by fire damage render most hardwoods unmerchantable. Allowance has been made for mortality of about 15 percent of gross annual growth.

(2) *Better-stocked shortleaf-loblolly-hardwood stands.*—Figure 14 (diagram B) and table 15 show stands that are in better condition to yield current returns when organized into forest properties than the average-stocked stands.

The cutting practice necessary to build up stands such as that shown in table 14 to take advantage of their earning possibilities consists in very light cuttings, returning to a given stand about once every 10 years. Not only will an effort be made to increase the number of smaller trees until the ground is as fully occupied as warranted by the characteristics of the species, but at each cut some of the thrifty larger trees will be held for further growth. Younger trees will gradually come up into the small timber class if seed trees of requisite number and age are present and fire does not destroy the seedlings. When the density of the stand has been fully built up cuttings will usually take the form of clean cutting groups and removing single trees as required throughout the intervening stand. Some of these scattered trees will be removed because fully matured in size and value, others will be thinned out of dense groups to give remaining trees more space. Each addition to the growing stock, up to a fairly high density, will add to the growth per acre and reduce the cost of production per 1,000 board feet. Small additions to the growing stock left at each cut insure an accumulation of volume far beyond the additions themselves. In other words, the rebuilding of the growing stock is more a matter of skillful handling than of financial sacrifice.

TABLE 15.—*Number of trees, volume, and growth, exceptionally well stocked shortleaf and loblolly pine with some hardwood stands in southern Arkansas*

Tree diameters at breast height	Trees per average acre					Average time required to grow to next diameter class		
	Shortleaf	Loblolly	Hardwoods	Total stand [1]	Defective, all species	Shortleaf	Loblolly	Hardwoods
Young stock:	*Number*	*Number*	*Number*	*Number*	*Number*	*Years*	*Years*	*Years*
2 inches	3.86	13.31	13.03	30.20	19.31	14	16	23
4 inches	7.17	11.72	7.03	25.92	8.07	12	14	23
Total	11.03	25.03	20.06	56.12	27.38			
Small timber:								
6 inches	9.10	13.38	9.10	31.58	5.93	12	12	18
8 inches	10.14	14.90	5.31	30.35	1.79	12	11	17
10 inches	12.21	14.28	4.69	31.18	1.32	12	10	17
12 inches	9.52	10.34	2.83	22.69	.76	13	9	17
Total	40.97	52.90	21.93	115.80	9.80			
Medium timber:								
14 inches	3.17	4.69	.96	8.82	.76	15	9	17
16 inches	1.24	4.34	.62	6.20	.69	17	8	17
18 inches	.34	1.66	.83	2.83	.35	19	8	17
20 inches	.14	1.17	.41	1.72	.14	20	8	17
Total	4.89	11.86	2.82	19.57	1.94			
arge timber:								
22 inches	.07	.62	.07	.76	.14	20	8	18
24 inches		.14	.07	.21	.07		8	18
26 inches		.07		.07			8	18
28 inches					.07			
Total	.07	.83	.14	1.04	.28			
Total for average acre	56.96	90.62	44.95	192.53	39.40			

TABLE 15.—*Number of trees, volume, and growth, exceptionally well stocked shortleaf and loblolly pine with some hardwood stands in southern Arkansas*—Continued

Tree diameters at breast height	Cubic volume[1]				Saw timber volume[1]	
	Shortleaf	Loblolly	Hardwoods	Total	Shortleaf	Loblolly
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Ft. b.m.*	*Ft. b.m.*
Young stock:						
2 inches	0.50	2.00	1.63	4.13		
4 inches	8.89	14.06	6.12	29.07		
Total	9.39	16.06	7.75	33.20		
Small timber:						
6 inches	38.95	54.59	22.20	115.74	109	201
8 inches	96.74	132.01	29.20	257.95	365	477
10 inches	208.79	223.20	49.81	481.80	1,062	957
12 inches	255.14	264.70	50.66	570.50	1,476	1,355
Total	599.62	674.50	151.87	1,425.99	3,012	2,990
Medium timber:						
14 inches	122.04	175.88	26.25	324.17	723	985
16 inches	64.73	223.94	24.14	312.81	386	1,341
18 inches	22.61	113.21	43.77	179.59	136	706
20 inches	11.59	98.40	28.18	138.17	71	638
Total	220.97	611.43	122.34	954.74	1,316	3,670
Large timber:						
22 inches	6.90	62.00	6.11	75.01	43	412
24 inches		16.10	7.79	23.89		109
26 inches		9.19		9.19		64
Total	6.90	87.29	13.90	108.09	43	585
Total for average acre	836.88	1,389.28	295.86	2,522.02	4,371	7,245

Tree diameters at breast height	Saw timber volume[1]		Average annual growth of saw timber[2]		
	Hardwoods	Total	Shortleaf	Loblolly	Total
	Ft. b.m.	*Ft. b.m.*	*Ft. b.m.*	*Ft. b.m.*	*Ft. b.m.*
Young stock:					
4 inches			3.1	3.5	6.6
Small timber:					
6 inches		310	15.8	16.4	32.2
8 inches	32	874	37.3	41.0	78.3
10 inches	197	2,216	60.0	79.2	139.2
12 inches	252	3,083	46.4	78.7	125.1
Total	481	6,483	159.5	215.3	374.8
Medium timber:					
14 inches	141	1,849	15.2	44.7	59.9
16 inches	136	1,863	5.6	54.5	60.1
18 inches	257	1,099	1.6	21.5	23.1
20 inches	174	883	.7	15.3	16.0
Total	708	5,694	23.1	136.0	159.1
Large timber:					
22 inches	40	495	.3	8.3	8.6
24 inches	53	162		1.9	1.9
26 inches		64		1.0	1.0
Total	93	721	.3	11.2	11.5
Total for average acre	1,282	12,898	186.0	366.0	552.0

[1] Defective trees not included.

[2] Defective trees and hardwoods not included. Hardwood is growing at the rate of about 50 board feet per acre per annum but defects caused chiefly by fire render most of hardwoods unmerchantable.

(3) *Longleaf pine* (*23*).—Average and better stocked stands of longleaf and slash pines are graphically represented in figure 15. Diagram A and table 16 are representative of an average stocked stand in Hamilton County, Fla. Diagram B shows a better stocked stand found in Bradford County, Fla. The average stand has about

one third the number of trees present in the better stocked stand. In both cases there is a moderate representation in the small timber group (6 to 12 inches diameter), very little in the medium timber group (14 to 20 inches diameter), and no large timber (22 inches diameter and larger).

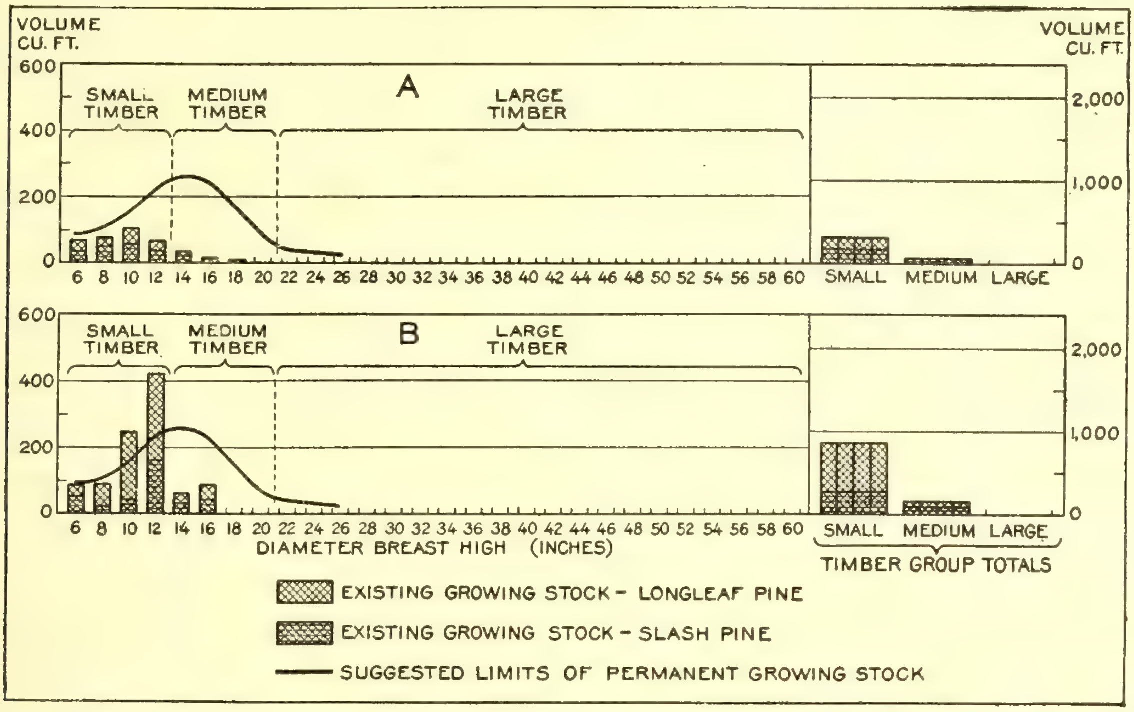
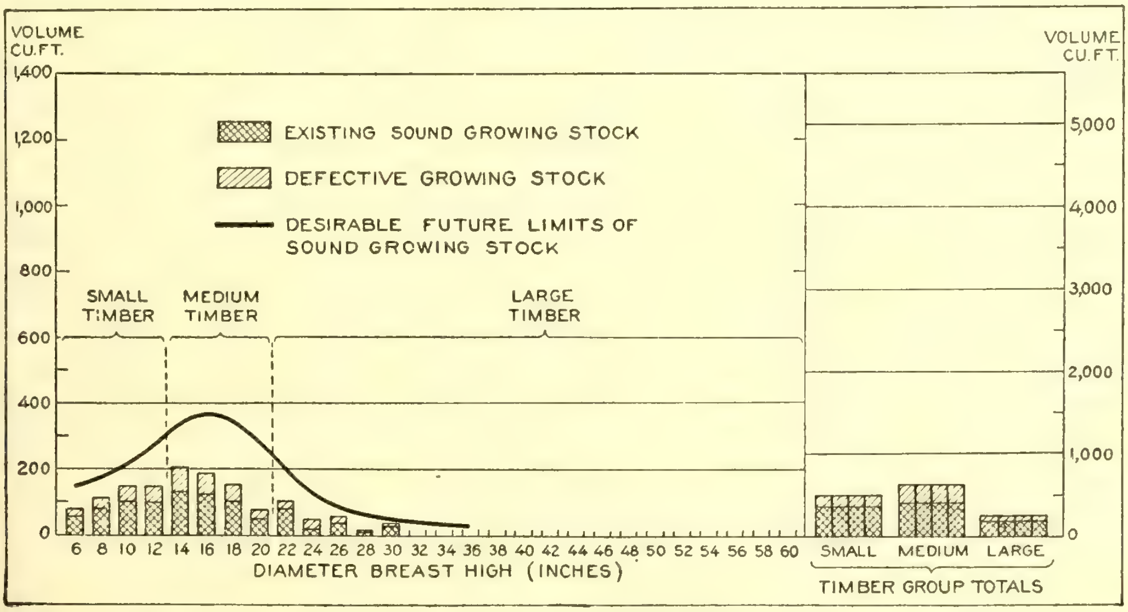


FIGURE 15.—Distribution of cubic volume by diameter classes on average acre longleaf and slash pine stands in naval-stores region. A, Average stocked stand based on sampling of 150,000 acres in Florida, said to be representative of 20,000,000 acres; B, better stocked stand based on inventory of 200 acres and said to be representative of 1,000,000 acres. Only a moderate permanent growing stock is recommended, owing to naval stores yields being higher from well-spaced trees.

Authorities hold that considerable areas of longleaf pine sites are too poor and the stands on them too badly depleted to warrant



GURE 16.—Distribution of cubic volume by diameter classes on average acre in river-bottom hardwoods, ased on strip tally of 10,000 acres, considered to be typical of about 25 percent of the 23,070,000 acres in his type.

eration by private capital. On good sites, with inadequate seed tees, planting is the proper procedure. This involves waiting a long tne for returns except where plantations are a part of otherwise tnbered properties.

(4) *Bottomland hardwoods (28).*—The bottomland hardwood stands include a great variety of hardwood species together with cypress. In table 17 these have necessarily been grouped into the principal genera. Figure 16 shows graphically the cubic-volume distribution of the same stand. These data are based on an inventory of 10,000 acres in south-central Louisiana and are believed to be typical of about 6 million acres in the type.

TABLE 16.—*Number of trees, volume, and growth in average stocked stand of longleaf and slash pine in Florida* [1]

Tree diameters at breast height	Number trees per average acre			Time required to grow to next diameter class		Cubic volume		
	Longleaf	Slash	Total	Longleaf	Slash	Longleaf	Slash	Total
Young stock:	*Number*	*Number*	*Number*	*Years*	*Years*	*Cubic feet*	*Cubic feet*	*Cubic feet*
Under 2 inches	9.28	1.90	11.18	--------	--------	--------	--------	--------
2 inches	18.02	8.99	27.01	6	6	1.80	0.90	2.70
4 inches	13.06	8.99	22.05	7	7	10.45	7.19	17.64
Total	40.36	19.88	60.24	--------	--------	12.25	8.09	20.34
Small timber:								
6 inches	12.14	13.13	25.27	8	7	36.42	36.76	73.18
8 inches	4.71	8.23	12.94	9	8	22.18	55.14	77.32
10 inches	3.31	4.62	7.93	11	8	45.68	60.06	105.74
12 inches	1.18	2.08	3.26	12	9	25.96	41.60	67.56
Total	21.34	28.06	49.40	--------	--------	130.24	193.56	323.80
Medium timber:								
14 inches	.63	.62	1.25	14	9	19.53	18.60	38.13
16 inches	.16	.24	.40	17	10	7.20	10.08	17.28
18 inches	.04	--------	.04	18	10	2.32	--------	2.32
20 inches	.02	.06	.08	22	10	1.40	4.20	5.60
Total	.85	.92	1.77	--------	--------	30.45	32.88	63.33
Total for average acre	62.55	48.86	111.41	--------	--------	172.94	234.53	407.47

Tree diameters at breast height	Saw timber volume			Average annual growth of saw timber [2]		
	Longleaf	Slash	Total	Longleaf	Slash	Total
Small timber:	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
6 inches	73	53	126	18.2	26.7	44.9
8 inches	104	189	293	16.1	29.3	45.4
10 inches	209	282	491	12.2	19.0	31.2
12 inches	138	218	356	4.9	9.9	14.8
Total	524	742	1,266	51.4	84.9	136.3
Medium timber:						
14 inches	115	100	215	3.3	4.2	7.5
16 inches	45	59	104	.6	1.7	2.3
18 inches	15	--------	15	.1	--------	.1
20 inches	9	25	34	.1	.3	.4
Total	184	184	368	4.1	6.2	10.3
Total for average acre	708	926	1,634	55.5	91.1	146.6

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[1] Said to be typical of 20,000,000 acres in naval stores region. Much of the growth is never utilized for saw timber, owing to use of trees for turpentining.

[2] The growth indicated is an approximation. The mortality was assumed to reduce gross volume growth by 25 percent.

TABLE 17.—*Number of trees, volume, and growth in typical stand second-growth, river bottom hardwoods in lower Mississippi Valley*

Tree diameters at breast height	Trees per average acre						Time required to grow to next diameter class			
	All oaks	Hick-ories	Gums	All others	Culls [2]	Total stand	All oaks	Hick-ories	Gums	All others
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Years*	*Years*	*Years*	*Years*
Young stock:										
2 inches	30.0	3.0	9.0	12.6	33.4	54.6	9	17	12	13
4 inches	20.0	2.2	7.0	10.8	14.5	40.0	9	17	12	13
Total	50.0	5.2	16.0	23.4	47.9	94.6	-------	-------	-------	-------
Small timber:										
6 inches	7.5	1.3	3.7	9.9	6.7	22.4	7	12	9	11
8 inches	5.3	.4	1.5	8.7	5.5	15.9	7	12	9	11
10 inches	3.5	.2	.7	7.6	3.7	12.0	7	12	9	11
12 inches	2.2	.2	.7	4.9	3.6	8.0	7	12	9	11
Total	18.5	2.1	6.6	31.1	19.5	58.3	-------	-------	-------	-------
Medium timber:										
14 inches	2.3	.1	.7	3.3	3.5	6.4	8	13	11	12
16 inches	2.3	.1	.4	1.5	2.1	4.3	8	13	11	12
18 inches	1.80	-------	.30	.45	1.10	2.55	8	13	11	12
20 inches	.65	.05	.10	.35	.45	1.15	8	13	11	12
Total	7.05	.25	1.50	5.60	7.15	14.40	-------	-------	-------	-------
Large timber:										
22 inches	.55	.10	.35	.30	.35	1.30	8	13	11	12
24 inches	.10	-------	-------	.25	.35	.35	9	17	12	13
26 inches	.15	-------	.15	-------	.20	.30	9	17	12	13
28 inches	.04	-------	.03	.02	.02	.09	9	17	12	13
30 inches	-------	-------	-------	-------	-------	-------	9	17	12	13
32 inches	.06	-------	.06	.03	.05	.15	9	17	12	13
Total	.90	.10	.59	.60	.97	2.19	-------	-------	-------	-------
Total for average acre	76.45	7.65	24.69	60.70	75.52	169.49	-------	-------	-------	-------

Tree diameters at breast height	Cubic volume						Saw timber volume	
	All oaks	Hick-ories	Gums	All others	Culls [2]	Total	All oaks	Hick-ories
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Bd. ft.*	*Bd. ft.*
Young stock:								
2 inches	6.0	0.6	1.12	1.26	4.74	8.98	-------	-------
4 inches	36.0	3.96	6.09	4.32	14.79	50.37	-------	-------
Total	42.0	4.56	7.21	5.58	19.53	59.35	-------	-------
mall timber:								
6 inches	30.00	5.20	9.0	16.83	18.16	61.03	-------	-------
8 inches	40.81	3.08	8.25	34.80	31.52	86.94	-------	-------
10 inches	42.70	2.44	7.43	56.24	37.26	108.81	-------	-------
12 inches	31.68	2.88	12.60	52.92	51.84	100.08	88	8
Total	145.19	13.60	37.28	160.79	138.78	356.86	88	8
edium timber:								
14 inches	62.10	2.70	18.90	50.92	80.99	134.62	161	7
16 inches	74.75	3.25	15.60	34.12	65.98	127.72	230	10
18 inches	74.16	-------	15.90	14.58	46.42	104.64	252	-------
20 inches	34.90	2.68	6.90	13.42	24.16	57.90	136	10
Total	245.91	8.63	57.30	113.04	217.55	424.88	779	27
rge timber:								
22 inches	33.60	6.11	30.45	14.11	22.76	84.27	143	26
24 inches	7.70	-------	-------	14.16	28.54	21.86	34	-------
26 inches	15.21	-------	21.00	-------	20.76	36.21	63	-------
28 inches	4.91	-------	5.22	1.74	2.56	11.87	19	-------
32 inches	10.00	-------	15.00	3.33	8.80	28.33	36	-------
Total	71.42	6.11	71.67	33.34	83.42	182.54	295	26
Total for average acre	504.52	32.90	173.46	312.75	459.28	1,023.63	1,162	61

TABLE 17.—*Number of trees, volume, and growth in typical stand second-growth, river bottom hardwoods in lower Mississippi Valley*—Continued

Tree diameters at breast height	Saw timber volume—Continued			Average annual growth of saw timber [1]				
	Gums	All others	Total	All oaks	Hickories	Gums	All others	Total
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
Small timber:								
12 inches	35	147	278	9.43	0.50	1.56	4.46	15.95
Medium timber:								
14 inches	49	132	349	8.62	.25	3.18	8.25	20.30
16 inches	48	105	393	11.50	.31	2.17	5.00	18.98
18 inches	54	50	356	15.75	------	2.45	1.50	19.70
20 inches	27	52	225	4.06	.19	.90	1.46	6.61
Total	178	339	1,323	39.93	.75	8.70	16.21	65.59
Large timber:								
22 inches	130	60	359	5.50	.62	3.82	1.25	11.19
24 inches	------	62	96	.89	------	------	.77	1.66
26 inches	87	------	150	1.00	------	1.25	------	2.25
28 inches	20	7	46	.27	------	.28	.05	.60
32 inches	54	12	102	.40	------	.55	.07	1.02
Total	291	141	753	8.06	.62	5.90	2.14	16.72
Total for average acre	504	627	2,354	57.42	1.87	16.16	22.81	98.26

[1] Only growth on sound trees has been calculated, but loss from mortality has not been deducted.

[2] Defective and suppressed trees not included in total effective growing stock.

Because of past cutting and considerable burning these stands include a volume of defective material sufficient to displace at least one third of the production that could be obtained if the growing stock were all of vigorous and well-formed trees. The problem of removing this material is difficult. Some of it, although unadapted to lumber use, can be cut into small-dimension material for furniture manufacture, stave bolts, railroad ties, or other uses. It may prove possible to remove from the stand by girdling large defective trees having no prospective value.

DETERMINATION OF GUIDING DIAMETER LIMITS FOR CUTTING

In the division of this section entitled, "Application of the Selective Cutting System," general principles on which trees should be selected for cutting were discussed in some detail. Some of the data used were drawn from the South. Figure 17, which bears on this subject as related to southern pines, is inserted here to show the relationship between cubic volume and board measure for trees of different sizes. It shows that trees 15 inches or more in diameter at breast height average about 185 cubic feet per 1,000 board feet. Trees from 8 to 14 inches in diameter contain about 250 cubic feet per 1,000 board feet. Disadvantages of producing lumber from southern pines less than 16 inches in diameter are as follows:

1. As much as 60 percent more volume must be grown to produce 1,000 board feet.
2. All this extra weight is expensive to handle. Partly for this reason, logging and milling costs are higher for these sizes.

3. To cut trees when they are small is to destroy them at just the time when they are beginning to yield their highest returns from growth, in volume and in quality. (See also pages 33–41.)

4. The lumber produced from the small sizes is much lower in grade and brings a lower price.

APPLYING SELECTION PRINCIPLIES IN THE MANAGEMENT OF SOUTHERN FOREST PROPERTIES

Since in the South extraction of timber is so simple and is carried on with such modest equipment, in that region it is wholly feasible to perate forest properties of very small size as well as those up to 100,00 acres or more.

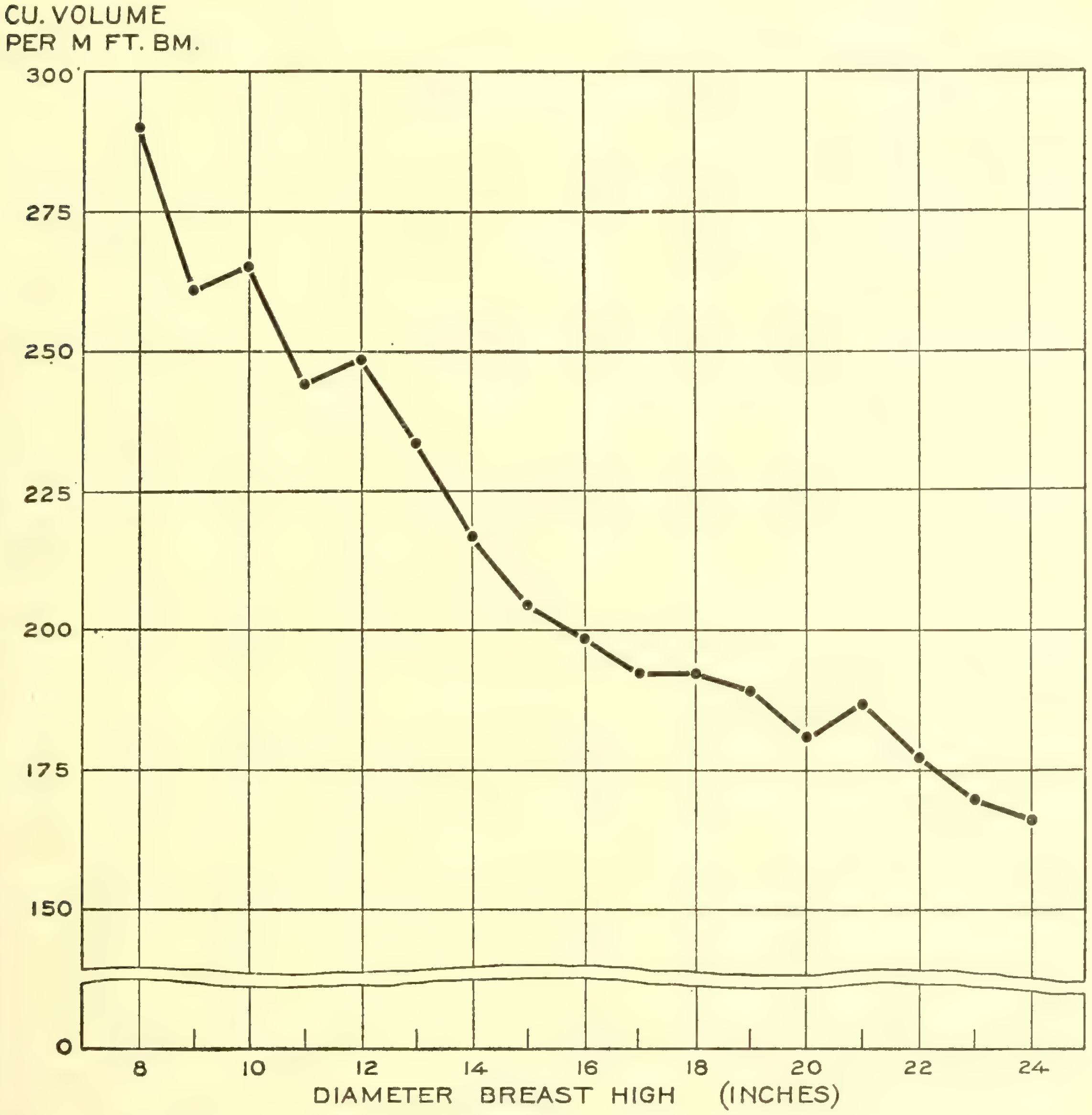

FIGURE 17.—Number of cubic feet tree volume (to 5-inch top) per thousand board feet—mill tally, southern pines.

In the case of farm woodlands, experience has shown that selling he output on the stump seldom results in satisfactory prices. The est practice is for the farmer to sell his forest products in harvested rm, as he sells his agricultural products. The same equipment, such s motor truck and teams, that is used in handling field crops can be evoted outside the crop season to getting out logs, pulpwood, etc. well-stocked 100-acre farm woodland may yield as much as 50,000 board feet of logs annually. This can be gotten out in a month's time or less, and if sold as logs may bring as much as $500.

The Bureau of the Census now recognizes "forest-products farms" statistically. Ordinarily such a farm produces vegetables, milk, and other food supplies for the owner, but the owner's cash income derives chiefly from the sale of forest products. If the owner is to make good use of his time throughout the year on his own property and on a basis of permanence he must assemble an area of 1,000 acres or somewhat more, of which he can cut over about 100 acres annually for logs and cordwood. This is assuming that trees over 17 inches in diameter are cut for saw logs and the tops cleaned up for pulpwood or other cordwood material. In addition smaller trees of poor form for further growth, or needing to be removed from too dense stands, will go into cordwood. If the enterprise is to have permanence and constantly improving income the owner must strive to leave each unit of the forest in better condition for growth after each cutting period.

The same principle holds with larger properties. The Southern Forest Experiment Station (*27*), in studying selective cutting in second-growth stands, has found that in mixed short-leaf-loblolly pine with hardwoods cut to a 17-inch diameter limit 4,836 board feet per acre of logs from trees over 17 inches can be produced in the 10 years following cutting. In this case study taxes, fire protection, and administrative costs involved in producing stumpage on this basis amounted to 18 cents per acre per year or $1.80 for 10 years, or 37 cents per 1,000 board feet. On the basis of 1929 selling prices the gross returns from stumpage utilized were $5.26 and net earnings were $5.08 per acre per year. From this is derived the profits on milling and logging operations as well as on the forest investment. The investment was $25 per acre, so that the investment earnings averaged 20.3 per cent net. The area studied is, no doubt, exceptionally favorable.

If the diameter limit on the same area is reduced to 13 inches the growing stock left will produce only 3,508 board feet per acre in 10 years. Cutting to a 13-inch limit also will yield less stumpage value than in the above case. The returns will be reduced to $2.35 per acre gross and $1.64 per acre net with a 10 year cutting cycle. Unfortunately the common practice is to cut far under 13 inches and practically destroy the productivity of the average forest for some time after cutting.

By surveying a tract of virgin timber by the same procedure the station found that if a 21-inch diameter limit were established an average of 4,000 board feet per acre could be produced in 10 years. The current cost of producing stumpage, returning for a cut every 10 years, would be 82 cents per 1,000 board feet. This larger stumpage is much more valuable and the net returns, on the basis of 1929 costs and sales prices, become $5.67 per acre. From this must be derived all profits on the entire operation. The investment in this case is $35 per acre.

The low production costs in these three examples are the result of moderate taxes and low costs of fire protection and administration, combined with rapid growth, in stands that have not been seriously depleted or overcapitalized. These low costs are immediately attainable only in stands already reasonably well stocked, a description that unfortunately fits only a rather low percentage of the southern forests. Other stands must go through a period of rebuilding the growing stock before they will give equal results. There are large areas in condition to yield a smaller net return during the rebuilding process.

It is clear that in the South, now that cutting operations in old-growth forests are approaching their end, owners of second-growth stands are fully justified in applying conservative management methods, particularly in observing cutting diameter limits not under 16 inches and building up the growing stock. Stumpage can be produced under these methods at a cost less than the accumulated holding charges that have now piled up against virgin timber. To build up the growing stock requires a reasonable degree of fire protection.

Costs of production have not been thoroughly studied in most other regions, but from general information now available it is safe to conclude that very few can equal the low costs shown in these examples.

The following quotation from a file report of the Southern Forest Experiment Station describes effective methods of managing longleaf-slash pine stands primarily for naval stores production (*23*):

> By far the most prevalent forest condition is that involving a group-selection stand, that is to say, several ages and sizes of trees intermingled on every acre. In some places large areas of second growth are found that are approximately even aged and more or less of the same size. In the future these areas will become more important. In general, the owner setting out to get full production will assemble as nearly as possible approximately equal stocking of the different age classes, and will constantly endeavor as operations proceed, by planting, by purchases, and by management itself, to improve the normality of his forest. His operations will involve (1) thinning his overstocked stands of young growth, possibly in two operations, the first when the trees are about 2 inches in diameter breast high and the second after the part of the stand to be removed has been turpentined; (2) turpentining the stand under conservative methods as long as profitable; (3) cutting the worked-out trees and obtaining a new stand, either naturally or by planting. The average rotation on the sites that will be handled under full-production management will be from 45 to 60 years.
>
> Absolute control of fire is an essential to full production. This involves complete protection of areas being restocked, and may or may not involve the use of fire as a protective measure in stands that are established. Fire control will be more expensive than for other types in the South, and complete immunity from fire damage is not to be expected.
>
> In the following example the measures proposed and their sequence are set out, together with the cost and returns per acre.
>
> The basic forest data were obtained from surveys made in Bradford County, Fla. The stand table and rate of growth are both based upon the better classes of forest land, such as would be chosen for intensive management. The forest portrayed is an all-aged, group-selection stand of longleaf and slash pine in which, at the beginning, 59 percent of the stems are longleaf and 41 percent are slash pine. The ages run from 1 year to 50 years. The diameters at breast height range from less than 1 inch to 16 inches. The stand per acre, at the beginning of management, is 283 stems, distributed as follows:

	Number	Percent
eedlings 2 inches or less in diameter	145	51.3
aplings 4 to 8 inches, inclusive, in diameter	96	33.9
urpentined trees 10 to 14 inches, inclusive, in diameter	40	14.1
aw timber 16 inches or more in diameter	2	.7
	283	100.0

The rate of diameter growth assumed is .31 inch per annum, which was the rate found generally on the better sites throughout Bradford County. This is conservative, as no increase is made on account of the improved growth conditions to be expected under management.

The forest is managed on a 48-year rotation, with a turpentine cycle of 8 years. The forest stand is thinned at the beginning of each 8-year period; the young stuff, 3 inches and under in diameter, standing as it does in thick clumps scattered over the area in the openings left by the removal, in previous operations, of the larger worked-out saw-timber trees, is thinned to an average stand of 80 trees per acre. At the beginning of management and in the eighth year this is the only thinning necessary, but in the sixteenth year and every eighth year thereafter the 8- and 9-inch trees, in addition, are thinned to 25 trees per acre. Before the trees to be removed are cut, they are worked for turpentine for 8 years. At the beginning of each 8-year cycle, the trees that have reached 9 inches diameter breast high are worked for turpentine under a conservative long-time method by which only one face is worked at a time. The first face is worked 7 years at the rate of 12 inches in height per season, after a rest period of a year the second face is started and carried for 7 years, there is another rest of one year, and the final face is placed and worked for 7 years. Then the tree is felled for saw timber. The opening resulting from the felling will restock naturally to slash pine seedlings. The first thinning, when the trees are between 6 and 12 years of age, costs 50 cents per acre, with no income; the thinning after turpentining in the 8-inch class pays for itself through the production of one cord of pulpwood per acre. The final cut is expressed in board feet, Doyle scale, with full deduction for cull caused by turpentining.

Fire protection is intensive, involving lookout towers, firebreaks, and organized personnel with equipment. It is assumed to be adequate to the extent of keeping at least 97 percent of the area free from uncontrolled fires, except for one serious conflagration such as may be expected in the pine belt on an average of once in 50 years. Losses due to this fire are included in the calculations of yield as running on from the middle of the rotation. Normal mortality throughout the rotation has been taken into account, in addition. Costs and returns for a 100,000 acre unit are shown below:

Average costs per acre per year:	
Protection and supervision	$0. 14
Taxes	. 20
Thinnings (every 8 years, at 50 cents)	. 06
Total	. 40
Average returns per acre per year:	
Naval stores rental from trees cut in thinning—2 cents per cup	. 41
Naval stores rental from trees of place, 4 cents per cup until trees become uniformly well spaced, then 5 cents per cup	2. 54
Saw-timber stumpage	. 48
Total	3. 43
Net annual returns per acre (average over a period of 48 years)	3. 03

The management outline given here is applicable to perhaps as much as 2 million acres of the better forest lands in the longleaf-slash pine type in north Florida and southeast Georgia, and elsewhere in the belt where forest conditions are similar.

In bottom-land hardwoods the chief management problem, due in considerable degree to careless management in the past, is how to eliminate the large percentage of defective growing stock. There is an opportunity also to improve the composition of the stand. These measures can be put into effect only gradually, as outlets are found for the lower-grade material.

It is believed that even this partial consideration of facts bearing on private forestry in the South fully warrants the conclusion that the time has arrived to apply organized management to the forests still in condition to provide adequate yields. These facts definitely show that without aid nature cannot continue to provide the great volumes of forest raw material which have supported much southern labor and provided an investment field for much capital during the past half century.

HARDWOOD FORESTS OF THE CENTRAL STATES

(Ohio, Indiana, Illinois, Iowa, Missouri, Kentucky, Tennessee, and West Virginia)

PRESENT CONDITIONS AND MANAGEMENT POLICIES

The Central States are primarily a hardwood region, although at the higher altitudes certain conifers appear in mixture with hardwood species. The States of the Ohio Valley in particular were originally clothed with magnificent forests of valuable hardwoods such as oak, black walnut, yellow poplar, and ash. As a large part of the land that was occupied by these forests is valuable for agriculture, much of the area was cleared by early settlers for that purpose.

At the present time it is estimated that the region has 63,477,000 acres of privately owned forest including 5,110,000 acres rated as poor to nonrestocking, 12,078,000 acres rated as fair to satisfactory stocking, 25,368,000 acres of cordwood areas, and only 20,921,000 acres of saw-timber areas. There are 32,158,000 acres of farm woodland and 31,319,000 acres in other types of private ownership. (See table 1.)

EXTENT TO WHICH FORESTRY IS BEING PRACTICED

In the Central States there are three classes of private owners having somewhat different interests in their forest properties, with the consequence that their reasons for practicing forestry differ to a considerable degree. First, there is the farm-woodland owner, whose forest holdings are so intimately associated with farm operations that they can not readily be segregated from farm areas. This class of holding will be discussed later. Second, there is a large class of owners who are not farmers but who have other reasons for holding land than timber production. In this region mining (principally coal) is an important industry. Areas owned as mining property within the region are estimated as follows (*28*):

	Acres		*Acres*
Ohio	500, 000	Missouri	650, 000
Indiana	450, 000		
Illinois	700, 000	Total	2, 300, 000
Iowa	(1)		

A small number of owners of mining property have realized that heir surface areas may as well be producing returns and have conequently initiated improved forestry practices. An added reason or the practice of forestry by these owners is that large quantities f mining timbers and other forest products are required in their wn operations. Unfortunately the area on which improved forestry ractice has been put into effect as a result of these considerations is ot large.

The third class of forest owners are those holding timberland for he major purpose of obtaining saw logs or other forest products rom the land. This category includes a number of pulp companies nd sawmill owners as well as owners of a large acreage not connected ith manufacturing enterprises. A small portion of the land owned y this class is being placed under continuous-yield management. revailingly, however, when any of this land is cut over it is cut so

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No data.

closely that no production of any importance can be obtained again within 60 to 75 years. A large proportion of this class of forest owners are paying very little attention to the permanent productivity of their holdings. As a class they have failed to grasp the principle that through a practice of light cuttings at any one time far higher-grade logs or other products can be obtained and that the trees remaining will lay on rapid growth and within 10 to 20 years provide another cut of equal amount.

The following statement summarizes reports by the Central States Forest Experiment Station as to the extent to which owners of the second and third classes are placing forest lands under management (*28*):

1. Independent or cooperative fire protection. Reports on this phase, somewhat incomplete, show 4,671,000 acres on which private owners participate in protective effort. State efforts add materially to this total.

2. Conservative cutting, planting, and other practices aimed at prolonging productivity of the forest. Reports show 1,560,000 acres on which some of these practices, principally selective cutting, are carried on.

3. Permanent ownership and organized sustained yield. Reports show 92,600 acres under this type of management. Some additional areas fall very little short of this classification.

It is apparent that only a relatively small proportion of the 31,319,000 acres of privately owned forest lands other than farm woodlands is under any definite mangement looking to permanent productivity. The reason assigned by local observers for this condition is that past cutting operatings have reduced growing stock to such a point that further yields will be too long deferred to interest private owners.

PRODUCTION AND CONSUMPTION OF FOREST PRODUCTS

Industrial and domestic use of timber began in the Central States at the same time when early settlers began destroying large quantites of timber in order to clear the land for agriculture. In the course of time an important manufacturing industry developed, devoted especially to manufacturing lumber, furniture, and other products from the hardwoods. In the agricultural portions of the region there has been a large decline in the number of mills and the volume of output. Many of the remaining mills have had to ship in raw materials from the rougher portions of this region and from the bottom-land hardwood lands of the Mississippi Valley. Mills throughout the region continue to draw to a considerable extent, however, on local sources of log supply, especially farm woodlands. Ninety percent of the log supply of mills in the Corn Belt is said to come from farm woodlands.

Table 18, based on census figures and Forest Service data, shows the production and consumption of lumber in these States. These statistics indicate a deficit of 6,568,987 thousand board feet in regional lumber production as compared with use of lumber. The greater part of the deficit is in softwoods, which do not grow in much of the region.

Large quantities of other forest products are produced and consumed in the region, including posts, poles, fuel wood, pulpwood, etc., but parallel statistics of production and consumption of these products are not easily available. This diversity of use has been pointed out as one of the leading elements facilitating complete utilization of saw-timber trees and the making of thinnings to improve younger stands. In the farm-woodland areas utilization is usually complete, owing to the diversity of wood uses on farms. More thought should be given to balanced use of the raw materials from the forests on other private lands.

TABLE 18.—*Lumber production and consumption in the Central States in 1928*

State	Lumber production [1]			Lumber consumption [2]
	Softwood	Hardwood	Total	
	M ft.b.m.	*M ft.b.m.*	*M ft.b.m.*	*M ft.b.m.*
Ohio	120	112, 109	112, 229	1, 522, 208
Indiana	21	126, 769	126, 790	837, 294
Illinois	484	29, 139	29, 623	2, 343, 258
Iowa [3]		13, 908	13, 908	980, 807
Nebraska				310, 690
Missouri	35, 272	106, 718	141, 990	762, 399
Kentucky	17, 050	157, 290	174, 340	451, 826
Tennessee	85, 592	444, 714	530, 306	802, 133
West Virginia	110, 383	437, 440	547, 823	235, 381
Total	248, 922	1, 428, 087	1, 677, 009	8, 245, 996

[1] Data from Forest Products, 1928: lumber, lath, and shingles. Bureau of the Census, 1930.
[2] Figures based on compiled data in the files of the Forest Service.
[3] Includes Kansas.

GROWING STOCK CONDITIONS

No stand tables are available for any of the hardwood forests which constitute the principal type of this region. The general condition of the stocking has been adequately described by State foresters and by members of the staff of the Central States Forest Experiment Station. These observers agree that the growing stock has seriously deteriorated in virtually all the hardwood forests. Conditions are considered especially serious in the farm woodlands, owing to grazing in addition to careless cutting. Farm-woodland deterioration is said to be more serious through the Corn Belt, where livestock is a very important factor in farm operation and where in consequence grazing use of woodlands is widespread.

MANAGEMENT OF FARM WOODLANDS

Authorities agree that if any woodland is to be preserved on the arm it should be segregated from the grazing areas. It is said that n the more hilly or mountainous parts of the Central States Region, ncluding large portions of Kentucky, Tennessee, and West Virginia, ncreasing attention is being given to the management of farm woodnds as a major source of farm income.

Some excellent examples of management occur even on areas of ss rough topography. A number of instances of this sort are cited i Farmers' Bulletin No. 1680 (*29*). Results obtained in certain Ohio communities which offer about the best examples of good farm-oodland management to be found in the region are described as follows by Mr. Ralph K. Day, of the Central States Forest Experiment Station (*28*):

> Probably the outstanding examples of what can be done in the way of profitable woodland management are to be found among the Mennonite and Amish communities of Ohio and Indiana. These thrifty people have for generations utilized the otherwise slack winter months for woods work. In this manner they keep themselves and their teams profitably employed the year round. One owner who has kept an accurate record of all cash sales from his woodland, has permitted an analysis of his timber operations since the war. During the 13 years from 1919 to 1931, inclusive, he has received in cash a total of $10,457.73 for the forest products cut from 75 acres of farm woodland. This represents a gross return of $10.73 per acre per year. The entire area is classified under the Indiana forest tax law, and the annual taxes probably do not exceed 10 cents per acre. Since no outside labor was employed and the work was done at times when the men and teams would otherwise have been idle, the per acre return compares very favorably with the gross return of less than $19 per acre for all cereals grown in Indiana in 1929. During the 13 years for which records are available this owner has cut, sold, and delivered 266 thousand board feet of hardwood logs at an average price of $35 per thousand board feet. In addition, he has sold and delivered 643 cords of fuel wood at an average price of $3.10 per cord and supplied his own needs for fuel wood to the extent of approximately 25 cords per year. This does not include an unestimated amount of fence post material and other timbers cut and used on the farm. Although over 700 board feet per acre have been cut during the last 2 years, the farm woods appeared to be at least 90 percent stocked at the time of examination. An analysis of the annual returns of 10 other Indiana classified woodlands has been made by T. E. Shaw, extension forester of Indiana. This analysis reveals net profits ranging from $1.10 to $6.25 per acre per year and disregards the intangible values in fuel, fence posts, and rough timbers cut and used on the farms.

Current depression conditions emphasize the fact that farmers are generally overlooking their woodlands as a source of annual income. The foregoing quotation also emphasizes the desirability of farmers marketing timber in the form of logs or other material ready for manufacture. It is a general experience that farm-woodland timber sold on the stump brings only a small fraction of its actual value. Even more serious is the destruction wrought by portable mills on such tracts. The timber is invariably cut below merchantable size and future returns thereby deferred for a generation or more.

MEASURES NECESSARY TO IMPROVE FORESTRY PRACTICES

It is obvious that private ownership will continue to be of great importance in this region. One measure that can help in improving forest productivity is equitable assessment and collection of taxes, which is discussed elsewhere in this report. Another such measure is promotion of the public attitude which favors precautions against forest fire, trespass, and other public injuries. In addition it is necessary, where large continuous areas of woodland are involved, to build up definite organizations for the purpose of fire protection. These subjects are discussed elsewhere in this report.

A third measure, which is indispensable in promoting better use of the forest area, consists in putting into the hands of forest owners the necessary information regarding the proper care of their properties. This involves three steps: First, research, which is discussed elsewhere in this report; second, the establishment of demonstration areas and community projects; and third, extension work. By extension work throughout the region State foresters and extension foresters have already brought about considerable improvement in management practices. These efforts need further support. In order to obtain more information and to set up definite demonstrations extra activity is justified in localities where manufacturing plants provide a balanced demand for forest products. Effort should be directed toward still further improvement of manufactured products through production engineering, and toward modification of raw-material purchasing methods to permit the best use of forest productivity. Cooperation of manufacturers with forest owners would enable the latter to build up growing stock and forest productivity through marketing forest raw material of the kinds that it is most desirable to remove.

FORESTS OF THE LAKE STATES REGION

(Michigan, Wisconsin, Minnesota, and North Dakota)

PRESENT CONDITIONS AND MANAGEMENT POLICIES

The Lake States were formerly a very important conifer region, of which the most characteristic type was the northern white pine forest. (North Dakota, which is here thrown in this group for statistical purposes, has very little forest area). Early settlement did not lag far behind that in the Central States, and the same practice of destroying timber to clear land was in effect for some time. The use of timber in industry was soon under way. Commercial production of forest materials started first in the agricultural settlements in the southern part of the region and was later extended into the forest areas to the north. The white pine forests, as the most valuable, were the scene of the earliest operations on a large scale. Commercial production of northern white pine had begun to expand by the end of the Civil War, and approached a maximum by 1882. At one time the annual regional cut of northern white pine rose to nearly 9 billion feet. Decline in production of white pine had set in by 1895 and has been more or less continuous down to the present day. The northern white pine type has now been almost entirely destroyed, and with the exception of some spruce and Norway pine the remaining conifers are of relatively inferior character. The coniferous forest has to a very large extent been superseded by inferior broad-leafed species, of which scrub oak and aspen are the most plentiful. In addition to the area now or formerly occupied by coniferous forests there is a considerable area of northern hardwoods (yellow birch, sugar maple, and beech) with hemlock. These northern hardwood and hemlock forests are the location of the principal remaining forest industry.

By the time the white pine industry had begun to decline the pulp and paper industry had begun to attain importance in the region. Large plants are located in Wisconsin, Minnesota, and Michigan. These plants are able to use trees of species and sizes that as a rule are of small value in the lumber industry. This provides conditions or balanced production in continuously operated forest properties; evenue from the sale of cordwood material to the pulp and paper mills helps the landowners to meet production expenses and lowers he cost of producing the more valuable saw-log material. Unfor-unately the stands have already deteriorated too far to provide the aw-timber constituents of the cut on a current basis. It appears, herefore, that the pulp and paper industry will have to rely largely n forests operated, for the present at least, mostly for the production f pulpwood. This means special capital investments in forests for this purpose, which is a rather severe handicap in comparison with the conditions in regions where saw timber furnishes sufficient returns to support forest investments and pulpwood is more or less of a by-product furnishing an added return. By saving portions of the stand at each cutting for further development, it is possible to rebuild stands to saw-timber production.

Table 1 credits the region with 49,073,000 acres of privately owned forests, of which 14,281,000 acres is farm woodland. As to general condition the forest land is classified as follows: Poor and nonrestocking, 12,133,000 acres; fair to satisfactory restocking, 24,683,000; cordwood, 7,833,000 acres; and saw timber, only 4,424,000 acres. It is clear that liquidation of the forest capital has proceeded farther than in any other major forest region. Local observers do not report very much evidence that this process has discontinued, and it seems probable that it will continue until the original forest area is reduced to a minimum. The final steps in this process will leave a huge area of very low-grade stands. Table 19 shows in some detail the present situation in forests other than farm woodlands.

TABLE 19.—*Commercial forest in private ownership in the Lake States in 1932* [1]

State	Areas [2] (thousand acres)	Ratio to total commercial forest area (percent)	Condition classes					
			Merchantable				Nonmerchantable	
			Saw timber		Cordwood		Restocking	Not restocking
			Thousand acres	Million board feet	Thousand acres	Thousand cords	Thousand acres	Thousand acres
Michigan	12,947	68	1,209	12,928	1,363	61,179	8,329	2,046
Minnesota	12,178	60	487	3,096	548	17,354	8,895	2,248
Wisconsin	9,617	59	932	6,343	1,267	38,010	6,170	1,248
Total	34,742	63	2,628	22,367	3,178	116,543	23,394	5,542

[1] Data from Forest Statistics for the Lake States, 1931, compiled by the Lake States Forest Experiment Station. Revised Mar. 30, 1932.
[2] Exclusive of farm woodlands.

PRODUCTION AND CONSUMPTION OF FOREST MATERIALS, AND STATUS OF LUMBER AND PAPER INDUSTRIES

Lumber production in the Lake States region is now relatively unimportant as compared with the great production of former years. The deficit in lumber production as compared with consumption in 1928 was 1,808,871,000 board feet. Table 20, based on census data, shows the production and consumption of lumber in these States in 1928, the latest year for which both production and consumption figures are available.

TABLE 20.—*Lumber production and consumption in the Lake States in 1928*

State	Lumber production[1]			Lumber consumption[2]
	Softwood	Hardwood	Total	
	M feet board measure	*M feet board measure*	*M feet board measure*	*M feet board measure*
Michigan	141,787	430,272	572,059	1,714,462
Wisconsin	352,548	466,302	818,850	1,030,501
Minnesota	359,618	52,725	412,343	725,825
North Dakota				141,335
Total	853,953	949,299	1,803,252	3,612,123

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[1] Data from Forest Products, 1928: Lumber, Lath and Shingles. Bureau of the Census, 1930.
[2] Figures based on compiled data in the files of the Forest Service.

Table 21 (*30*) shows the statistical position of the lumber and paper industries in the region in 1929. The value of the paper-industry products was rated as more than twice that of the products of the lumber industry.

TABLE 21.—*Statistical position of lumber, pulpwood, and paper industries, Lake States, 1929*[1]

State	Lumber industries				
	Number of establishments	Salaried men and average number of wage earners	Salaries and wages	Value of products	Quantity of lumber produced
			Thousands of dollars	*Thousands of dollars*	*M board feet*
Michigan	294	17,554	23,701	68,885	571,017
Minnesota	191	8,066	10,174	30,839	357,180
Wisconsin	346	24,514	28,604	82,369	842,814
Total	831	50,134	62,479	182,093	1,771,011

State	Pulp and paper industries				
	Number of establishments	Salaried men and average number of wage earners	Salaries and wages	Value of products	Quantity of pulpwood produced
			Thousands of dollars	*Thousands of dollars*	*Cords*
Michigan	53	13,572	21,717	106,004	313,477
Minnesota	13	2,811	4,146	28,317	266,320
Wisconsin	79	14,513	20,765	129,459	1,233,962
Total	145	30,896	46,628	263,780	1,813,759

[1] Census of Manufactures, 1929, Industry Series.

EXTENT TO WHICH PRIVATE FORESTRY IS BEING PRACTICED

In the Lake States, as in the Central States, three classes of owners re to be considered. The first class, the farm-woodland owners, ave problems very similar to those in the Central States. The second class, those who are not farmers but nevertheless have other reasons for holding forest land than the production of timber, are probably less numerous than in the Central States since the mineral area is less in this region. This class is augmented to some extent by those holding land for recreational purposes.

The third class, those holding timberland primarily for the purpose of producing forest products, hold nearly all the commercial forest lands in the region other than farm woodlands. This class is generally characterized by uniting manufacturing enterprises with timber holding. The union of these two types of enterprises seems to encourage hasty liquidation of the forests rather than to retard it. The large capital investment in the manufacturing enterprise generally results in a desire to operate continuously to keep the capital from being idle. Where these two distinct forms of capital investment are kept separate, there is not nearly so much pressure toward operating. The mill owner, not having so many taxes and other fixed overhead charges to meet, is in a position to restrict his operations to periods when some profit can be obtained; and the forest owner soon learns by experience that it is good business to dispose of sufficient timber in times of active demand to create financial reserves sufficient to carry him through periods of low demand. The forest owner of necessity takes constant note of the movement of stumpage prices. This is greatest during periods of change from depression to prosperity; at those periods, therefore, accumulation of profit from holding stumpage is most rapid. Obviously, disposal of stumpage or saw logs at the low point of depression periods represents a large loss to be guarded against where possible by preparing in advance for these contingencies.

The following summary of reports by the Lake States Forest Experiment Station indicates the extent to which forest owners other than farmers are placing forest land under management.

1. Fire protection, independent or in cooperation with States. State-wide fire protection is furnished by public agencies in all these States. Lumber companies provide special fire protection for their logging operations and cooperate with the States in protecting their lands. The region has one forest-protective association. This association, in northern Minnesota, with State cooperation maintains organized protection on 125,000 acres of timberland.

2. Conservative cutting and other practices aimed at prolonging productivity of the present stand. It is estimated that all but 4 of the 34 remaining large mills will be cut out in the next 12 to 15 years. This means that a sustained-yield policy was not considered early enough. Selective logging, planting, and similar measures are practiced to some extent. The exact acreage is not reported, but 100,000 acres is mentioned as having been purchased by companies to build up production of pulpwood. One company is providing sufficient acreage to yield a second cut. Plantations totaling 28,000 acres had been established by 1930. No definite plans for sustained yield are reported.

From this summary it is clear that of the huge area of privately owned forest land very little is under any management looking to continued productivity.

GROWING-STOCK CONDITIONS

No detailed stand tables are at hand for any of the stands in this region. The general condition of the growing stock can be inferred from what has already been stated in describing the history of cutting operations. The areas formerly occupied by coniferous forests now have very poor stands of aspen and other inferior species. The growing stock in the remaining northern hardwood forests possesses considerable similarity to the growing stock in hardwood forests in the Middle Atlantic and New England States (see fig. 18), except that in the latter regions more or less cutting has been going on in most stands. In the Lake States the hardwood forests are in general being cut over for the first time, except that on some areas white pine intermingled with other species was removed long ago. Most observers agree that for this reason larger tree sizes are to be found and the product is perhaps somewhat higher in quality than that taken from the forests of the same species in the northeastern region.

FUTURE PROSPECTS FOR PRIVATE FORESTRY

Mr. Raphael Zon, who has given a great deal of thought to present and future forest conditions in the Lake States, predicts (*30*) that about 6 million acres in Michigan, Wisconsin, and Minnesota will eventually be put under rather intensive private forestry management. Mr. Zon estimates that only 14,200,000 acres of additional forest will be placed under intensive management in Federal, State, and county ownership within the near future. This will leave 39,600,000 acres in all classes of ownership under nonintensive management. According to this estimate, prospects for the reestablishment of large forest production in the region in the immediate future are not particularly good. It appears that the region, having a large resident population and being close to other great centers of population, will for some time constitute a large market for the forest products of other regions.

Most of the forest area in this region represents, from the forest-productive standpoint, an example of conditions discussed earlier in this section, wherein practically all the capital required for forest production has been removed. On huge areas not more than 1 to 5 percent of the necessary capital (inclusive of the value of the land) is present. To restore production on these areas will require not only heavy money investments but a considerable period of time. The region is confronted with a forest-reclamation project of great magnitude.

The forests of aspen and other inferior species are an example of mpoverished resources such as Americans have not yet had to deal vith on many areas. Where a resource has been brought into such condition but a population remains to live from it, both labor and apital must operate on a reduced scale of income if at all until the esource is restored. On the other hand, owing to the near exhaustion f the forests in the Lake States, local forest industries are relieved of ompetition to the approximate extent of freight rates from the acific Northwest or to the South. It is essential both to the economic and to the social well-being of the region that large forest areas within easy reach of transportation facilities of the Great Lakes or of centers of population be restored to productivity. This job will require public assistance through many if not all of the channels discussed elsewhere in this report. No single method will solve the problems involved.

FORESTS OF THE NEW ENGLAND AND MIDDLE ATLANTIC STATES

(Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, Delaware, and Maryland)

PRESENT CONDITIONS AND MANAGEMENT POLICIES

The New England and Middle Atlantic States include most of the centers of early settlement by British and Dutch colonists in North America. Since virtually all the land surface was covered with forests, it was necessary to destroy considerable forest growth in order to clear agricultural land. As in the case of other eastern forest regions, industrial use of the forest began at the time of settlement by whites and has continued down to the present day. Partly because of the mixed character of the stands, which included species of high, medium, and low value, the forest in much of these regions has never been devastated to the degree that has occu red in regions having forests of a few high-value species. The fact that the precipitation is well distributed is another large factor in preserving the forest growth. Owing to the early development of the industry, the devastation that did occur in such types as the white pine and hemlock culminated in the latter part of the nineteenth century. On the whole, the value of the forest stands shows considerable recovery from its extreme low point. The types in which cutting has been in progress for centuries, and the types that were clean cut and now have young stands reestablished, are to a considerable extent still in a deteriorated condition from the standpoint of the character of the growing stock present. This condition, together with the steps necessary to correct it, will be discussed later.

According to the best available estimates (table 1) these regions have 50,909,000 acres of privately owned forests, including 15,863,000 acres of farm woodlands. Of this total, 5,286,000 acres is rated as poor to nonrestocking, 10,923,000 acres as fair to satisfactory restocking, 14,239,000 acres as bearing cordwood stands, and 20,461,000 acres as bearing saw-timber stands. In addition to these areas now in forest, there are large areas of abandoned nonforested farm lands available for afforestation.

More detailed information is available for Pennsylvania than for the other States of these regions. Here large areas were cut over on a nonselective basis. This occurred principally in two types—the northern white pine-hemlock, which yielded sufficient values to encourage clear cutting, and the hardwood types, clear cut because of the demand for mine timbers and distillation wood, both of which can be obtained from small-sized trees. These clear-cutting operations, followed by repeated fires for many years, have resulted in considerable devastation. With the establishment of State fire protection in recent years the devastated area has diminished materially. The Pennsylvania Department of Forests and Waters within the last few years made a rather careful survey of the condition of the forest areas of that State, which revealed 11,489,225 acres of large forest areas and 1,716,775 acres of areas not exceeding 50 acres completely or partially surrounded by cleared land. These small areas may be considered as composed entirely of farm woodlands. Considerable woodland owned by farmers is included within the large forest areas, also. The total forest area was classified as follows:

1. Lands burned until practically no forest growing stock remains (now occupied by bracken, huckleberries, briars, fire weeds, etc.), 300,668 acres.
2. Brush lands (now occupied by scrub oak, fire cherry, and aspen, occasionally with low sprouts of valuable tree species), 1,565,508 acres.
3. Young forest growth (valuable growth, up to a diameter of 6 inches, taking the lead over brush), 7,594,418 acres.
4. Merchantable timber (stands in which more than 50 percent of the trees are 6 inches or over in diameter), 3,745,407 acres.

Comparison of these data with reports of 15 to 20 years ago (*31*) seems to show that conditions have materially improved in recent years. It is reasonable to attribute this improvement to the substantial realization of objectives set up by foresters and public officials about 30 years ago, which, with support from the public, began to be realized during the last 20 years. These objectives centered largely around fire protection.

EXTENT TO WHICH PRIVATE FORESTRY IS BEING PRACTICED

These regions, also, have three classes of private forest owners. Ownership of forest land incidental to the holding of other resources is widespread; recreational use of land and control of water resources are more or less joined with forest ownership, and in Pennsylvania it s reported that 6,600,000 acres of forest land is owned in connection with mineral resources. To a considerable degree ownership of commercial timberlands is tied up with manufacturing enterprises, specially pulp and paper mills.

Many privately owned areas have been yielding forest crops at hort intervals from the time of the earliest settlement. Until within the last quarter century this continuous yield, generally peaking, took place without much intent on the part of the forest wner. Originally it came about through the practice of first cutting from the forest only the high-grade species such as northern white ine. After a few years cutting would be undertaken on the same rea for some other species that had become valuable. The openings made in the forest by this type of cutting became restocked with oung trees. Some of the species, such as the northern hardwoods, spruce, and hemlock, were uneven aged to begin with. The natural orm of the forest together with the system of partial cuttings resulted, over large areas, in forests of a rough selection form. Unfortunately, because of lack of effort to remove inferior trees and a general practice o taking the best species and best-formed trees the productive cpacity is far below what it would be under a well-planned application of the selection system, which systematically eliminates poor ad ineffective growing stock and builds up effective growing stock.

Owing to the prevalence of public fire-protection activities, considerable growth is being produced on a great deal of forest land which without such public fire protection would continue in a very low state of productivity. Reports (*32*) as to areas being managed under one or another of three grades of forestry practice are summarized as follows:

1. Fire protection by States, independently or with the cooperation of landowners. On the basis of long experience in attempting to control forest fires, landowners in these regions have generally come to rely almost entirely upon public fire protection, to which the Federal Government contributes as provided by the Clarke-McNary law. Practically the entire forest area is protected. The basis of fire protection in these States is fully covered elsewhere in this report. Private owners assist in fire prevention and fire suppression with their own forces. In the Maine forest district a millage tax is levied for fire-protective purposes.
2. Conservative cutting, planting, thinnings (including insect-control thinnings), etc., aimed at prolonging the productivity of the present stands but not definitely organized for sustained yield. Forest areas to the extent of 5,497,300 acres, including farm woodlands, are reported to be held by owners consciously making efforts to prolong or build up the productivity of their holdings. There is no doubt that relative safety from fire, due to nearly adequate public fire protection, has made it possible for private owners to improve their forest practices and to feel financially secure in so doing. In addition to the area consciously subjected to improved management practices 3,583,000 acres of land is reported to be handled under partial-cutting systems.
3. Sustained-yield management. Reports (*32*) show 648,592 acres, not including farm woodlands, now organized under definite sustained-yield programs. As a whole, therefore, the progress in these regions is encouraging. Vast areas remain, however, to be brought under organized sustained-yield management.

PRODUCTION AND CONSUMPTION OF FOREST PRODUCTS

Since these regions contain the largest centers of population in the United States, they are very heavy consumers of forest products. Throughout a long period of their history they produced sufficient forest products for their own needs, with the exception of a few kinds of material not producible in the region. For more than half a century, however, they have been importing increasing quantities of forest products of all kinds, chiefly from other portions of the United States and from Canada. The shortage in local production has created a favorable market situation for most of the local forest raw material. The wood-manufacturing industries have in many cases suffered severely, however, from the inadequacy of supplies of suitable material. Over a long period of time the raw material of better species and grades has been approaching depletion. Consequently local industries have had either to make use of poorer raw material or import from a distance. The measures necessary to correct this situation are discussed later. Table 22 shows the production and consumption of lumber in each of these States and in the regions as a whole in 1928.

TABLE 22.—*Lumber production and consumption in the New England and Middle Atlantic States in 1928*

State	Lumber production [1]			Lumber consumption [2]
	Softwood	Hardwood	Total	
	M ft.b.m.	*M ft.b.m.*	*M ft.b.m.*	*M ft.b.m.*
Maine	240, 569	25, 954	266, 523	262, 259
New Hampshire	211, 190	28, 071	239, 261	225, 873
Vermont	53, 527	53, 831	107, 358	116, 725
Massachusetts	78, 585	33, 714	112, 299	908, 057
Connecticut	9, 878	25, 478	35, 356	300, 083
Rhode Island	1, 815	2, 807	4, 622	160, 299
New York	32, 166	97, 940	130, 106	3, 088, 022
Pennsylvania	84, 185	154, 430	238, 615	1, 760, 030
New Jersey	102	3, 118	3, 220	834, 643
Delaware	10, 926	2, 235	13, 161	48, 137
District of Columbia				47, 471
Maryland	29, 533	30, 196	59, 729	511, 946
Total	752, 476	457, 774	1, 210, 250	8, 263, 545

[1] Data from Forest Products, 1928: Lumber, Lath, and Shingles. Bureau of the Census, 1930.
[2] Figures based on compiled data in the files of the Forest Service.

The deficit of lumber production shown is 7,053,295,000 board feet. In these regions the consumption of virtually every kind of forest product is very heavy. Pulp and paper are probably next in importance to lumber. For most forest products that can be produced in the regions, a market is available at no great distance.

GROWING-STOCK CONDITIONS

Stand tables are available for stands of five of the types which occur n these regions. It is not known over how much area these tables ctually apply. Stand conditions are shown for four different localiies as discussed in the following.

NORTHERN HARDWOODS IN THE WHITE MOUNTAINS AND IN THE ALLEGHENY MOUNTAINS (*32*)

These stands are made up of similar species, with sugar maple, ellow birch, and beech as the most common. Growth rates are vailable only for the White Mountain stand. It is probable that the rowth rates in the Allegheny Mountains differ to some extent owing climatic factors. Stands of this type are common in the northern rts and at the higher altitudes farther south throughout the regions. gure 18 shows the distribution of cubic volume in each stand and ble 23 shows the details of conditions in the White Mountain stand. he stands are in need of management to remove inferior species and ees and build up a growing stock with a reasonable representation of rger diameter classes. The principal difficulty in the way of this ocedure is the lack of market for the kind of materials such a cutting actice would yield. In many localities where a market for fuel or her small-size products exists, however, it is possible to carry out erations of this kind.

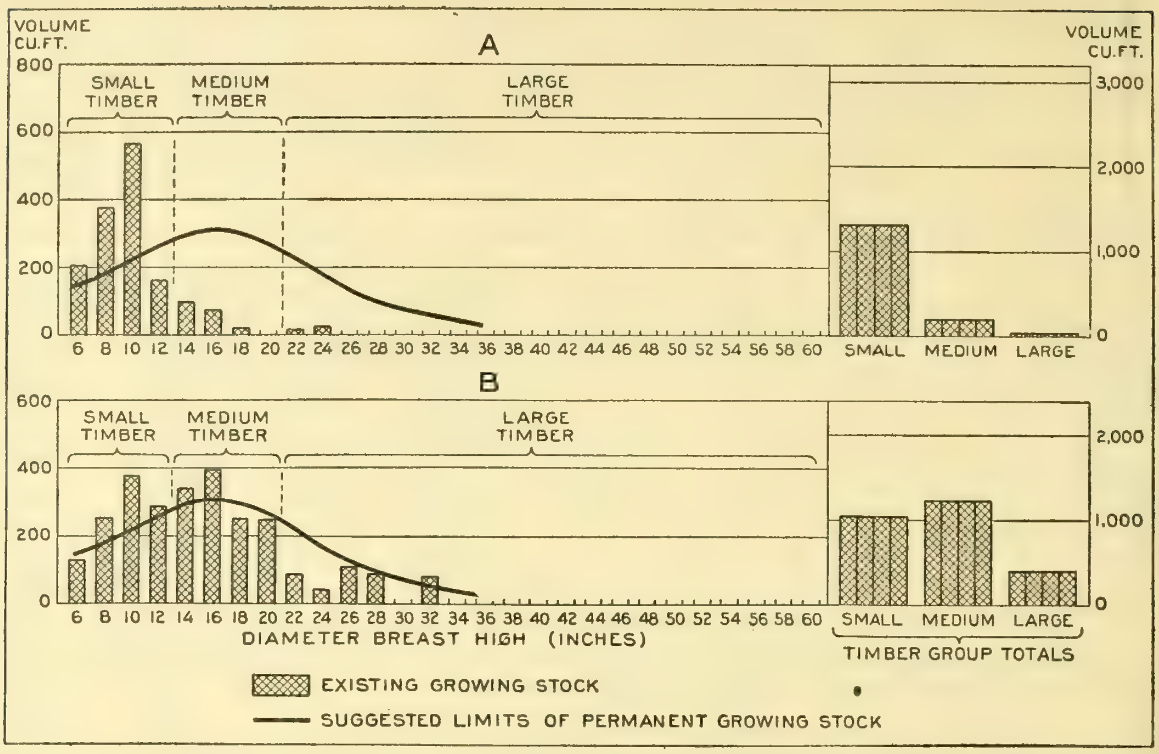

FIGURE 18.—Distribution of cubic volume by diameter classes on average acre, northern hardwood second-growth stands, with some timber left from previous stands. A, Stand in White Mountains. Thinnings from inferior species among the small timber would remove surplus from that group and hasten growth of released trees into larger groups; B, represents average of considerable areas in Pennsylvania. Distribution of size classes is better, but larger classes need building up.

TABLE 23.—*Number of trees, volume, and growth in all-aged northern hardwood stand in northern White Mountains, New Hampshire*

Tree diameters at breast height	Trees per average acre						Time required to grow to next diameter class	
	Red spruce and hemlock	Beech	Sugar maple	Yellow birch	Other hardwoods	Total stand	Conifers	Hardwoods
Young stock:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Years*	*Years*
2 inches	37.50	90.75	22.50	10.75	9.75	171.25	71	59
4 inches	12.50	62.50	13.75	8.75	13.00	110.50	62	38
Total	50.00	153.25	36.25	19.50	22.75	281.75	---	---
Small timber:								
6 inches	1.50	23.25	10.00	10.50	8.75	54.00	62	28
8 inches	---	17.75	7.00	9.25	6.25	40.25	59	22
10 inches	.50	15.50	5.50	4.75	8.50	34.75	55	20
12 inches	.50	1.25	2.50	1.50	1.25	7.00	53	20
Total	2.50	57.75	25.00	26.00	24.75	136.00	---	---
Medium timber:								
14 inches	.25	1.50	.75	---	.25	2.75	50	21
16 inches	.25	.25	.50	.50	.25	1.75	48	22
18 inches	---	.25	---	---	---	.25	---	25
20 inches	---	---	---	---	---	---	---	29
Total	.50	2.00	1.25	.50	.50	4.75	---	---
Large timber:								
22 inches	---	---	---	---	.25	.25	---	36
24 inches	---	---	---	---	.25	.25	---	50
Total	---	---	---	---	.50	.50	---	---
Total for average acre	53.00	213.00	62.50	46.00	48.50	423.00	---	---

TABLE 23.—*Number of trees, volume, and growth in all-aged northern hardwood stand in northern White Mountains, New Hampshire*—Continued

Tree diameters at breast height	Cubic volume						Saw-timber volume		
	Red spruce and hemlock	Beech	Sugar maple	Yellow birch	Other hardwoods	Total	Red spruce and hemlock	Beech	Sugar maple
	Cubic feet	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Board feet*	*Board feet*	*Board feet*
Young stock:									
2 inches	3.75	27.22	2.25	2.15	2.34	37.71			
4 inches	7.50	112.50	6.88	5.25	20.80	152.93			
Total	11.25	139.72	9.13	7.40	23.14	190.64			
Small timber:									
6 inches	5.25	120.90	19.00	22.05	37.62	204.82			
8 inches		193.48	56.00	76.78	53.75	380.01		302	168
10 inches	6.70	288.30	82.50	70.30	124.95	572.75	25	775	270
12 inches	9.65	34.75	57.75	33.45	27.25	162.85	35	110	192
Total	21.60	637.43	215.25	202.58	243.57	1,320.43	60	1,187	630
Medium timber:									
14 inches	6.50	61.20	24.08		7.38	99.16	25	195	87
16 inches	9.70	14.22	21.30	21.40	9.75	76.37	40	46	78
18 inches		18.58				18.58		62	
Total	16.20	94.00	45.38	21.40	17.13	194.11	65	303	165
Large timber:									
22 inches					17.90	17.90			
24 inches					21.08	21.08			
Total					38.98	38.98			
Total for average acre	49.05	871.15	269.76	231.38	322.82	1,744.16	125	1,490	795

Tree diameters at breast height	Saw-timber volume—Continued			Average annual growth of saw timber [1]					
	Yellow birch	Other hardwoods	Total	Red spruce and hemlock	Beech	Sugar maple	Yellow birch	Other hardwoods	Total
	Board feet	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
Small timber:									
8 inches	194	150	814		26.6	8.0	13.0	6.8	54.4
10 inches	247	408	1,725	0.2	29.4	7.7	7.1	9.8	54.2
12 inches	123	89	549	0.3	2.6	4.9	2.5	1.9	12.2
Total	564	647	3,088	0.5	58.6	20.6	22.6	18.5	120.8
Medium timber:									
14 inches		26	333	0.3	3.9	1.4		0.4	6.0
16 inches	82	34	280	0.3	0.7	1.0	1.0	0.4	3.4
18 inches			62		0.8				0.8
Total	82	60	675	0.6	5.4	2.4	1.0	0.8	10.2
Large timber:									
22 inches		64	64					0.3	0.3
24 inches		75	75					0.2	0.2
Total		139	139					0.5	0.5
Total for average acre	646	846	3,902	1.1	64.0	23.0	23.6	19.8	131.5

[1] No information available on tree mortality and no deduction has been made for this factor. Net growth may not exceed 75 percent of the total growth shown. Growth on smaller trees cannot be computed in board feet.

SPRUCE FLAT TYPE

This is representative of spruce stands which occur on rather limited areas in Maine, New Hampshire, Vermont, and northern New York. For the past quarter century or more there has been a very active demand for spruce pulpwood throughout the spruce region. The tendency, therefore, has been to keep the spruce cut out of the forest, to rather low diameter classes. There is some question at the present time as to whether a cutting procedure that will build up stock of higher diameter classes may not be desirable on account of the slackening in the demand for pulp sizes and on account of the possibility of getting a better price for at least a portion of the material. Figure 19 and table 24 show details of growing-stock conditions in an example of this type.

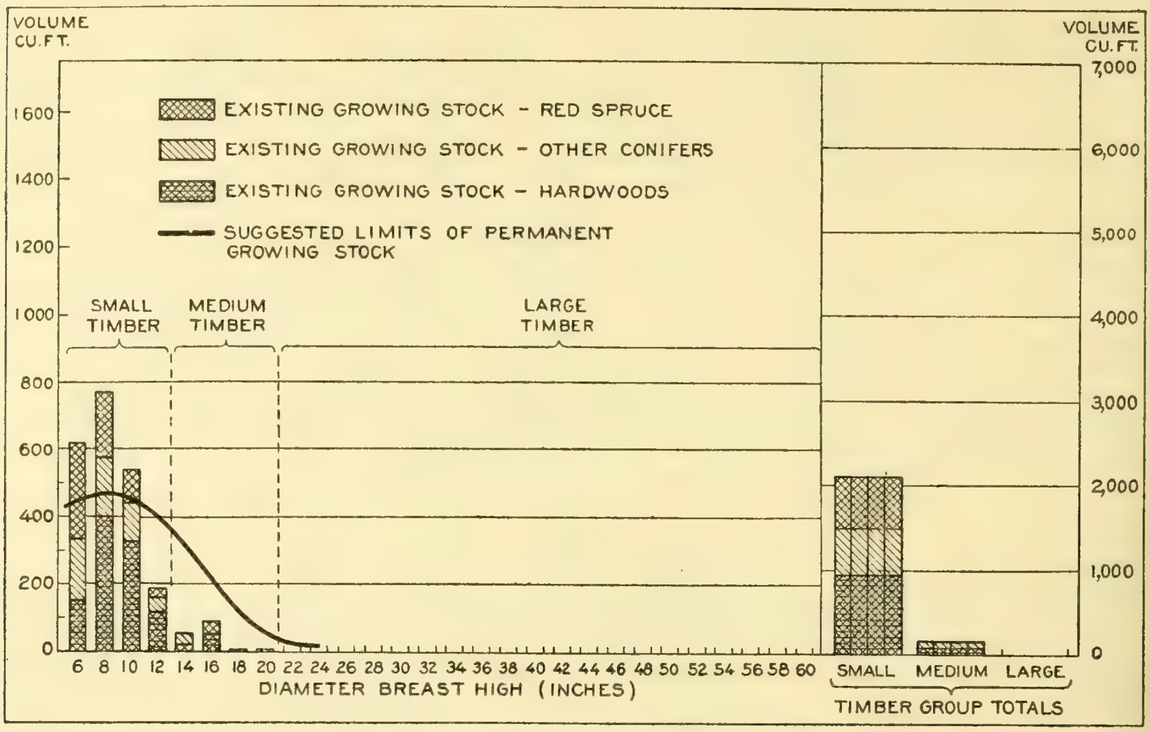

FIGURE 19.—Distribution of cubic volume by diameter classes on average acre, red spruce flat, White Mountains. Although most of the timber falls in the small timber group, it is probably not feasible to build up the larger diameter classes materially excepting the white pine and some of the associated hardwoods.

TABLE 24.—*Number of trees, volume, and growth in red spruce flat type in White Mountains, N.H.*

Tree diameters at breast height	Trees per average acre			Number years required to grow to next diameter class		Cubic volume		
	Red spruce	Hardwoods	Total stand	Red spruce	Hardwoods	Red spruce	Hardwoods	Total
Young stock:	*Number*	*Number*	*Number*	*Years*	*Years*	*Cubic feet*	*Cubic feet*	*Cubic feet*
2 inches	141. 26	111. 18	252. 44	71	59	14. 13	22. 23	36. 36
4 inches	145. 37	105. 49	250. 86	62	38	87. 22	63. 29	150. 51
Total	286. 63	216. 67	503. 30			101. 35	85. 52	186. 87
Small timber:								
6 inches	82. 23	73. 65	155. 88	62	28	287. 80	154. 66	442. 46
8 inches	27. 43	48. 38	75. 81	59	22	192. 01	401. 55	593. 56
10 inches	6. 97	22. 26	29. 23	55	20	93. 40	329. 45	422. 85
12 inches	1. 54	5. 28	6. 82	53	20	29. 72	117. 74	147. 46
Total	118. 17	149. 57	267. 74			602. 93	1, 003. 40	1, 606. 33
Medium timber:								
14 inches	. 11	. 63	. 74	50	21	2. 86	20. 16	23. 02
16 inches	. 17	. 17	. 34	48	22	6. 60	72. 76	79. 36
18 inches	. 06		. 06	45		. 29		. 29
20 inches				43				
Total	. 34	. 80	1. 14			9. 75	92. 92	102. 67
Total for average acre	405. 14	367. 04	772. 18			714. 03	1, 181. 84	1, 895. 87

TABLE 24.—*Number of trees, volume, and growth in red spruce flat type in White Mountains, N.H.*—Continued

Tree diameters at breast height	Saw-timber volume			Average annual growth of saw timber [1]		
	Red spruce	Hard-woods	Total	Red spruce	Hard-woods	Total
	Board feet	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
Small timber:						
8 inches	549	1,016	1,565	13.9	68.2	82.1
10 inches	348	1,158	1,506	2.5	33.4	35.9
12 inches	108	433	541	.9	8.7	9.6
Total	1,005	2,607	3,612	17.3	110.3	127.6
Medium timber:						
14 inches	11	72	83	.1	1.5	1.6
16 inches	27	28	55	.2	.4	.6
18 inches	13		13	.1		.1
Total	51	100	151	.4	1.9	2.3
Total for average acre	1,056	2,707	3,763	17.7	112.2	129.9

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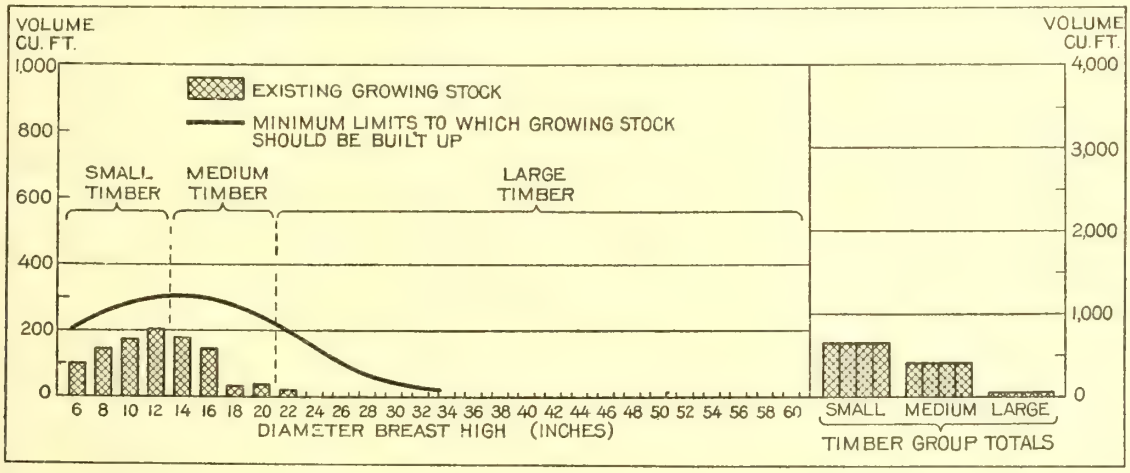
[1] No deduction has been made for tree mortality, losses from wood-rotting fungi, etc. Net growth may not exceed 75 percent of the total growth shown. Growth on smaller trees not computed in board feet.

OAK-HARDWOOD TYPES IN CONNECTICUT

The two stands represented in figures 20 and 21 have been under good management for over 25 years. Two or three cuttings have een made during that period and have considerably improved the tands. There still appears to be a need of building up the growing tock, especially in the higher-diameter classes. Small trees that are ot producing current growth of as high value as larger trees would roduce tend to occupy too great a part of the area.



IGURE 20.—Distribution of cubic volume by diameter classes on average acre, southern New England hardwoods, light stand.

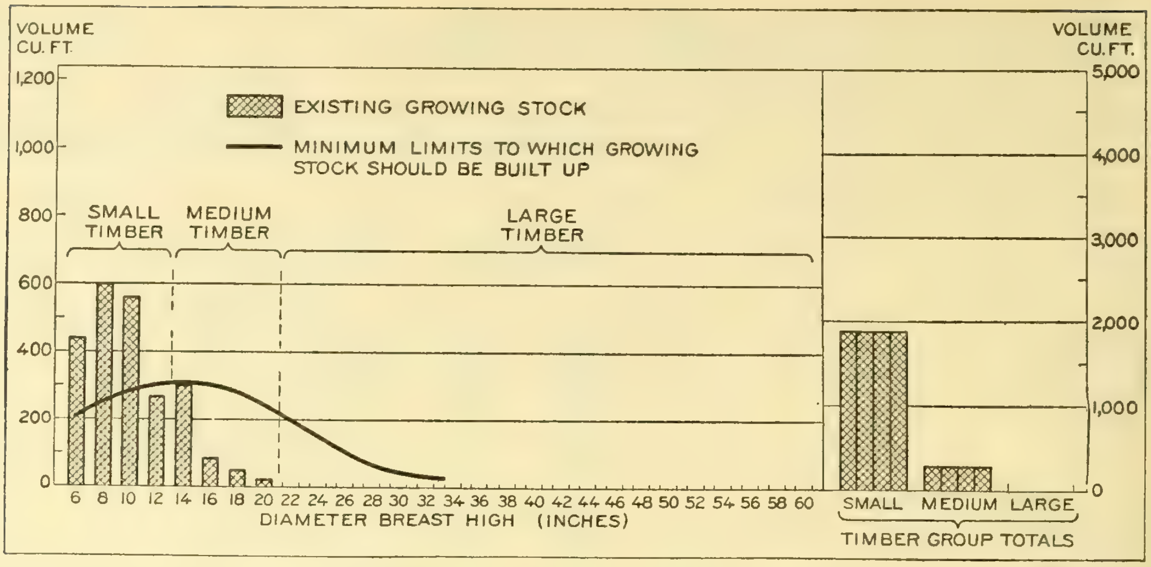


FIGURE 21.—Distribution of cubic volume by diameter classes on average acre, southern New England hardwoods, heavy stand.

TABLE 25.—*Number of trees, volume, and growth in well stocked many-aged stand oak with other hardwoods on Mont Alto State Forest, Pa.*

Tree diameters at breast height	Trees per average acre				Time required to grow to next diameter class—oak, tupelo, white ash and other hardwoods	Cubic volume	
	Oak	Tupelo and white ash	Other hardwoods	Total stand		Oak	Tupelo and white ash
Young stock:	*Number*	*Number*	*Number*	*Number*	*Years*	*Cubic feet*	*Cubic feet*
1 inch		2	118	120			0.4
2 inches	4	8	132	144	17	1.7	2.0
3 inches			36	36	10		
4 inches	2		20	22	10	3.4	
Total	6	10	306	322		5.1	2.4
Small timber:							
5 inches	2		14	16	14	4.8	
6 inches	2		8	10	14	6.6	
7 inches			6	6	6		
8 inches	4	2	6	12	18	34.6	16.2
9 inches	2	4	4	10	12	28.4	26.0
10 inches	2		2	4	20	37.2	
11 inches	4			4	17	78.8	
12 inches	4	2	4	10	16	98.6	47.4
Total	20	8	44	72		289.0	89.6
Medium timber:							
13 inches		2	6	8	9		40.4
14 inches		2	2	4	11		62.0
15 inches		2	2	4	5		68.0
16 inches	4	2	4	10	7	183.6	84.0
17 inches	4	2	2	8	9	207.0	96.8
18 inches	2			2	6	119.8	
19 inches	6			6	6	404.2	
20 inches	2			2	18	145.0	
Total	18	10	16	44		1,059.6	351.2
Large timber:							
21 inches	8			8	7	699.4	
24 inches	2	2		4	6	211.0	194.2
25 inches	2			2	10	217.4	
26 inches	2			2	7	217.4	
27 inches		2		2	6		219.4
28 inches	2			2	5	222.6	
Total	16	4		20		1,567.8	413.6
Total for average acre	60	32	366	458		2,921.5	856.8

TABLE 25.—*Number of trees, volume, and growth in well stocked many-aged stand oak with other hardwoods on Mont Alto State Forest, Pa.*—Continued

Tree diameters at breast height	Cubic volume—Continued		Saw-timber volume				Average annual growth of saw timber—oak, tupelo, white ash and other hardwoods
	Other hardwoods	Total	Oak	Tupelo and white ash	Other hardwoods	Total	
	Cubic feet	*Cubic feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
Young stock:							
1 inch	9.6	10.0					
2 inches	30.0	33.7					
3 inches	27.0	27.0					
4 inches	28.0	31.4					
Total	94.6	102.1					
Small timber:							
5 inches	33.0	37.8					
6 inches	32.8	39.4					
7 inches	30.6	30.6					
8 inches	61.6	112.4	84	40	140	264	2.9
9 inches	49.8	104.2	76	130	170	376	4.2
10 inches	31.0	68.2	110		110	220	2.4
11 inches		78.8	268			268	3.0
12 inches	93.0	239.0	352	200	380	932	10.4
Total	331.8	710.4	890	370	800	2,060	22.9
Medium timber:							
13 inches	150.0	190.4		190	640	830	9.2
14 inches	70.8	132.8		270	330	600	6.7
15 inches	70.0	138.0		350	290	640	7.1
16 inches	173.2	440.8	880	400	780	2,060	22.9
17 inches	83.8	387.6	1,120	460	330	1,910	21.2
18 inches		119.8	620			620	6.9
19 inches		404.2	2,360			2,360	26.2
20 inches		145.0	870			870	9.7
Total	547.8	1,958.6	5,850	1,670	2,370	9,890	109.9
arge timber							
21 inches		699.4	4,780			4,780	53.1
24 inches		405.2	1,260	1,100		2,360	26.2
25 inches		217.4	1,500			1,500	16.7
26 inches		217.4	1,490			1,490	16.5
27 inches		219.4		1,560		1,560	17.3
28 inches		222.6	1,600			1,600	17.7
Total		1,981.4	10,630	2,660		13,290	147.5
Total for average acre	974.2	4,752.5	17,370	4,700	3,170	25,240	280.3

OAK-CHESTNUT TYPE ON THE MONT ALTO STATE FOREST, PA. (*33*)

In the stand represented by figure 22 and table 25 chestnut has ben killed out by the chestnut blight and has been almost completely rplaced by other hardwood species. The stand has had excellent cre for a quarter century or more, with cuttings which removed iferior trees and species. In this way its growing stock has been bilt up far beyond what will ordinarily be found within privately oned forests. During this building-up process large volumes of tiber have been harvested and efficient fire protection has been pvided at all times. Only through such procedure can private oners obtain profitable returns from their holdings. The growing stck limits suggested are averages applying to an entire compartmnt where cuttings are made periodically.

WHITE PINE-HEMLOCK TYPE IN PENNSYLVANIA (*32*)

he stand represented by figure 23 and table 26 is an example of a ery small remnant of forests which formerly occupied large areas in Pennsylvania. Not enough of such forests is left to be of any immediate importance from the standpoint of management. The stand is of interest, however, as showing that the virgin forests of the region formerly contained a very heavy growing stock. Good management necessitates building up stands toward that condition, but, of course, not to the full degree shown by the virgin forests.

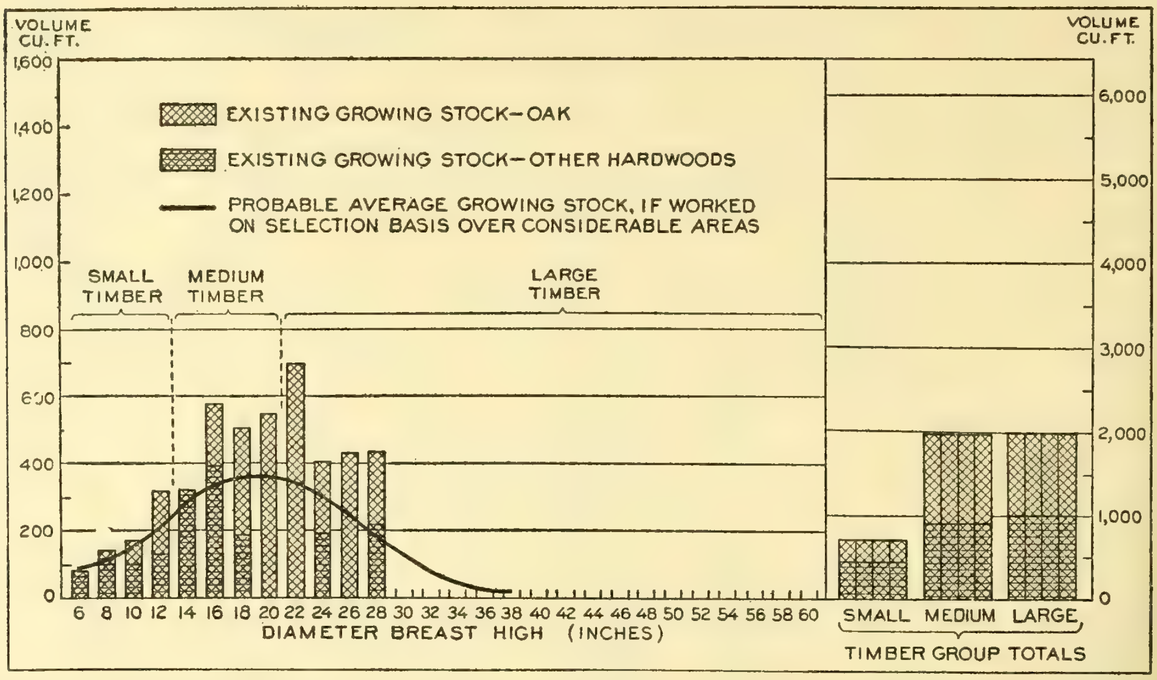


FIGURE 22.—Distribution of cubic volume by diameter classes on average acre, well-stocked oak-hardwood forest, from ½-acre plot, Mont Alto State Forest, Pa. Very few stands in the region outside the State forest have such excellent stocking.

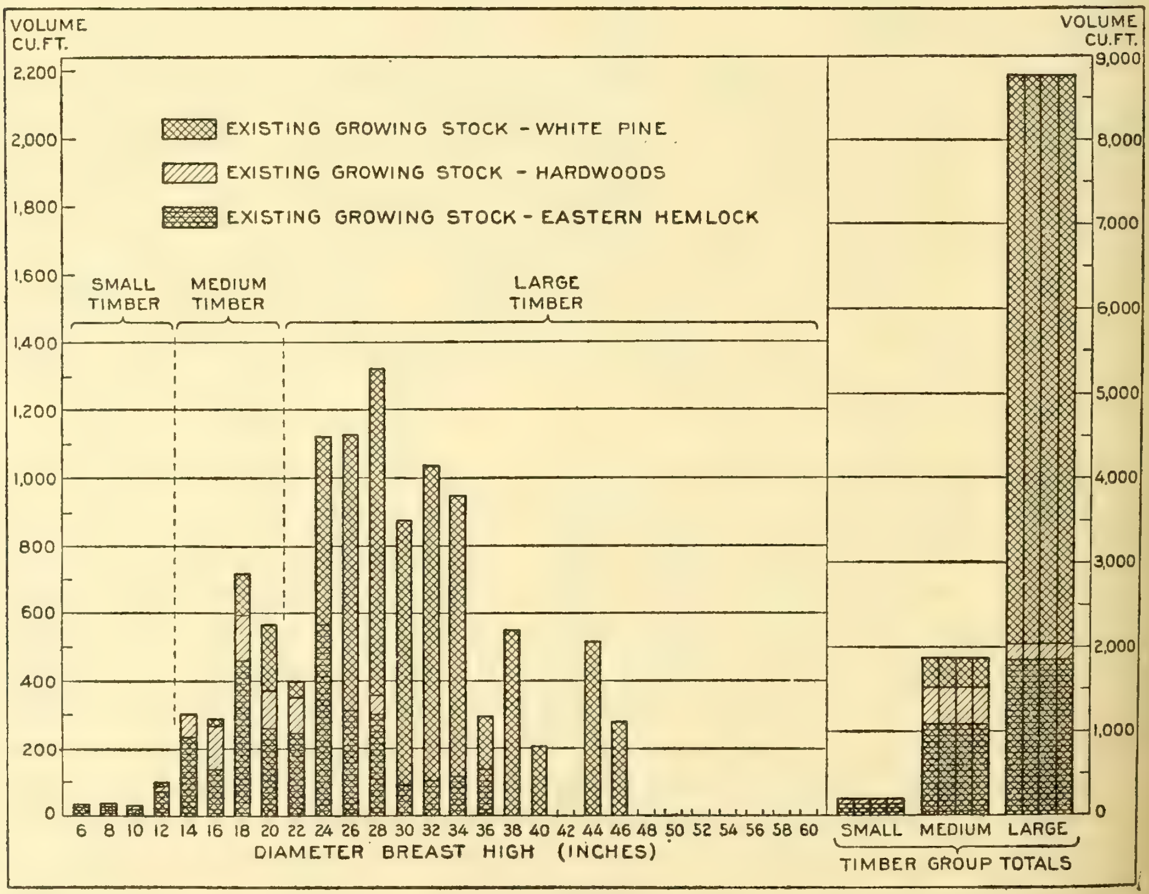


FIGURE 23.—Distribution of cubic volume by diameter classes on average acre, virgin white pine, Pennsylvania.

TABLE 26.—Number of [illegible] virgin stand of white pine, hemlock, and hardwoods, Pennsylvania

Tree diameters at breast height	Trees per average acre				Cubic volume				Saw-timber volume			
	White pine	Hemlock	Hard-woods	Total stand	White pine	Hemlock	Hard-woods	Total	White pine	Hemlock	Hard-woods	Total
	Number	*Number*	*Number*	*Number*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Board feet*	*Board feet*	*Board feet*	*Board feet*
Young stock:												
2 inches		144.0	296.8	440.8		28.8	89.0	117.8				
4 inches		11.2	12.0	23.2		11.2	8.4	19.6				
Total		155.2	308.8	464.0		40.0	97.4	137.4				
Small timber:												
6 inches		8.8	2.8	11.6		26.4	7.3	33.7			70	70
8 inches		4.0	.4	4.4		32.0	3.1	35.1		100	16	116
10 inches		1.6	.4	2.0		24.0	6.2	30.2		64	21	85
12 inches	0.4	3.2	.4	4.0	13.2	76.8	8.6	98.6	48	160	28	236
Total	.4	17.6	4.0	22.0	13.2	159.2	25.2	197.6	48	324	135	507
Medium timber:												
14 inches		6.8	2.4	9.2		238.0	67.4	305.4		544	223	767
16 inches	.4	2.8	2.8	6.0	24.0	137.2	127.7	288.9	104	336	448	888
18 inches	1.6	7.2	2.4	11.2	123.2	460.8	139.2	723.2	560	1,368	504	2,432
20 inches	2.0	3.2	1.6	6.8	196.0	262.4	114.4	572.8	920	832	448	2,200
Total	4.0	20.0	9.2	33.2	343.2	1,098.4	448.7	1,890.3	1,584	3,080	1,623	6,287
Large timber:												
22 inches	.4	2.4	1.2	4.0	48.0	247.2	107.8	403.0	238	864	432	1,534
24 inches	4.0	4.4		8.4	568.0	563.2		1,131.2	3,775	2,200		5,975
26 inches	4.8	2.0		6.8	816.0	312.0		1,128.0	4,488	1,240		5,728
28 inches	4.8	1.6	.4	6.8	979.2	300.8	58.0	1,338.0	5,496	1,200	272	6,968
30 inches	3.2	.4		3.6	784.0	89.2		873.2	4,416	380		4,796
32 inches	3.2	.4		3.6	934.4	104.0		1,038.4	5,248	456		5,704
34 inches	2.4	.4		2.8	829.8	118.4		948.2	4,632	544		5,176
36 inches	.4	.4		.8	160.8	134.4		295.2	898	680		1,578
38 inches	1.2			1.2	552.0			552.0	3,096			3,096
40 inches	.4			.4	208.8			208.8	1,172			1,172
42 inches												
44 inches	.8			.8	520.0			520.0	2,896			2,896
46 inches	.4			.4	284.8			284,8	1,564			1,564
Total	26.0	12.0	1.6	39.6	6,685.8	1,869.2	165.8	8,720.8	37,919	7,564	704	46,187
Total for average acre	30.4	204.8	323.6	558.8	7,042.2	3,166.8	737.1	10,946.1	39,551	10,968	2,462	52,981

FURTHER MEASURES NECESSARY TO IMPROVE FORESTRY PRACTICE

While it is probable that considerable additional forest areas will be taken into public ownership in these regions, all observers agree that great areas of forest land will remain in private ownership. The relation of forest taxation to the problems of private forestry is handled elsewhere in this report. Public fire protection is generally effective and only needs strengthening in certain localities. These foundations for private forestry having been laid, the time has arrived when it is possible to press forward to other necessary measures of improvement.

Of the remaining measures needed to improve the quality and increase the volume of forest production throughout the two regions, the most important is to revise cutting methods, with greater attention to saving the right kind of growing stock. This would mean as complete displacement of defective and inferior growing stock as could gradually be brought about. The demand for fuelwood should be met by this material together with otherwise unmerchantable parts of saw-timber trees. There is also need of the development of manufacturing practices through which inferior trees that should be thinned from the stands could be utilized for many of the products commonly used locally. It has already been mentioned that the older manufacturing plants are more or less handicapped owing for one thing to lack of local supplies of raw material of the quality they were designed to use. There is good reason to believe that methods can be developed which will obviate this handicap.

In order to accomplish this, close cooperation between forest owners, manufacturers, and technicians is needed. Any improvement in manufacturing practice which permits the use of small-sized material will damage rather than improve the forest conditions unless the cuttings are rigidly held to the kind of material that should be removed from the stands. The realization of some returns by labor or even some small return from stumpage in premature cuttings can never take the place of the far greater return to all participants in the industry when a reasonable proportion of the stand is left to reach full development before cutting. Once the growing stock is built up it will be a fairly simple matter to maintain it by silvicultural methods.

The coordinating influence of public agencies will be needed to bring to bear the vast fund of existing technical information applicable to such projects.

The first attempts at such improvements in manufacturing practice should be centered in communities where the cooperative spirit exists between forest owners and manufacturers and where the manufacturing enterprises are well adapted or can be adapted to utilization of the forest raw material that is available. Further investigation should be carried on in these places at the same time the existing knowledge is put into use.

The woodworking plants in the regions are widely diversified as to the products they manufacture; in this aspect the situation is excellent. Since many of these plants are old, it is evident that some new plants will be needed as time goes on. These should be located very carefully with respect to transportation of raw materials to the plants and finished goods to market. Earnest attention should be given to modern design in accord with the best principles of production engineering and to adaptation of technical processes. Finally, the folly of locating in a single community plants in excess of the productive capacity should be scrupulously avoided. Efforts to rebuild the forest capital cannot be expected to succeed if the wastage that accompanied early exploitation of the forest is allowed to continue.

MEASURES NECESSARY TO SPEED UP ADOPTION OF IMPROVED FOREST-MANAGEMENT PRACTICES

In handling the relatively small areas of well-stocked forest that now remain, together with such areas as have partially restocked and have promise for the future, the time element is of great importance. Neither the forest owners, the forest regions, nor the Nation can afford to allow the forest productivity to go into further decline. In many localities a relatively few years' prolongation of a liquidation policy would set back for a generation the opportuuity for private forestry to yield any immediate profit. In order to present a well-rounded picture of the measures involved in placing private forestry on a firm foundation, it is necessary to touch briefly on certain matters which have been discussed more fully earlier in this section, and also to touch on certain items which have not been treated in this section but have been treated fully elsewhere in this report.

CONSOLIDATING AND STABILIZING FOREST-LAND OWNERSHIP

As was noted earlier in this discussion, operating economy can be very materially advanced, both as to utilization of the present stand and as to permanent sustained-yield operation, by carefully assembling areas into natural economic units. The savings from proper size, shape, topographical form, and timber-transport facilities are, of course, most apparent in regions of rough topography such as is common in the West. Even on flat areas, location with regard to rivers, highways, railroads, manufacturing centers, and local markets is of great importance.

In order to take advantage of these savings all classes of owners in a given territory may well join in breaking the area into effective operating units. Each unit can then be transferred to a single ownership or the various owners can cooperate formally or informally in locating manufacturing plants and transportation routes, allocating the annual cut among various properties, etc. In working out these transfers and plans the aim should be to promote stability of ownership.

If the private owner is not interested in permanent ownership and care of this area, it is in his interest to maintain it in the best condition possible until it can be transferred to some stable form of ownership. Irresponsible ownership of forest areas is no longer justifiable.

ORGANIZING AND ADMINISTERING THE FOREST BUSINESS

Poor planning is as costly in forest business operations as in other lines of business. One of the first steps to be taken by the forest owner who has sensed the continuous-production possibilities of his holdings is systematic organization of the business. This means carefully eliminating many losing practices such as cutting stands and trees prematurely and constructing unnecessary improvements of only temporary value. It will provide for going over the property in an orderly manner within 5 or 10 years to harvest timber that is financially mature and salvaging where possible fungus-infected, insect-killed, windfall, and fire-scarred timber. It will also provide for a systematic gradual development of permanent transportation facilities and other forest improvements and for fire protection. Even on the property with impaired growing stock this systematic procedure accompanied by limitation of the cut will gradually rebuild the growing stock and productivity of the area. The systematic operation and the permanent improvements will also widen the margin of profit on stumpage cut. Above all it is necessary to remember that, as shown in the discussion of management of shortleaf loblolly pine stands in the South, well-stocked stands produce from two to three times as much per acre as poorly stocked stands, although taxes and the costs of fire protection and administration usually amount to no more per acre in the well-stocked stands. The cost of producing stumpage is, therefore, two to three times as great in poorly stocked forests.

ELIMINATING FROM COMMERCIAL FOREST AREAS PUBLIC SERVICES UNNECESSARY TO FOREST USE

Scattered settlement throughout forest areas creates, according to American standards, the need for schools, roads, and other services scattered through the areas. Such services cannot be supplied economically under these conditions and the result may be tax rates which, in themselves, tend to make forest use unprofitable. Normally, all but a small percentage of the labor required by forest industries is concentrated at manufacturing plants or elsewhere rather than scattered through the forest area. It is only in this manner that permanent living accommodations of the better class can be provided. This concentration is to the advantage of both employer and employee. Such communities can be supplied with public services economically and without imposition of an undue tax.

RESEARCH AND DEMONSTRATION

The general subject of forest research is discussed in another section of this report. Since forest ownership and also the manufacture of forest products is mostly in small units, forest research for the most part is carried on by public agencies. Such research has had very marked results in the past few years, but existing facilities for bringing these results to bear on the management of private forests have not proved altogether adequate. To meet this situation there is need to single out in each region a number of enterprises and a number of communities in which research workers, forest owners, and forest industries can cooperatively demonstrate the application of existing knowledge to some of the many problems remaining to be solved. These include:

1. Forest-growing problems, particularly that of removing the proper trees from the stand to obtain current income and at the same time prepare the stand to increase more rapidly both in volume and in volume.

2. Wood-utilization problems, particularly that of developing methods of getting out the numerous classes of forest raw materials most economically and without damage to the remaining stand. Closely connected with this problem is that of preparing and grading forest raw materials in a manner to adapt them as closely as possible to the requirements of manufacturers. At the present time large losses occur because various products are manufactured from logs of wholly unsuitable size and quality.

3. Manufacturing problems: The largest such problem, one which must rapidly grow more accure, is that of utilizing logs or bolts from inferior trees or species. Closely related to this is the division of manufacturing processes among different plants. At the present time large quantities of lumber having numerous defects are shipped to furniture manufacturers and other users of small clear pieces of wood. Since this involves waste of from 30 to 50 percent of the volume, important savings in transportation and often in manufacture can be effected by performing the initial manufacturing operations nearer the source of the timber. This procedure may result also in saving much timber too low in grade to be manufactured into lumber.

4. Marketing problems: Much remains to be done in this field, including educating the public to put each species to its proper use. Because liberal supplies of "all-purpose" woods have been available until within rather recent years, the growing need to discriminate in using lumber and other forests products of different species has been little realized.

5. The problem of correlating and coordinating all activities that touch the forest: This is the only means of stopping the present widespread waste both of forest products and of forest productivity and of preserving and building up forest productivity. It is entirely reasonable to expect that if this problem is solved in numerous communities and enterprises scattered throughout the forest regions, the example will be followed by other communities and enterprises. It is here proposed that investigation, demonstration, and extension be carried on jointly in selected communities and that increase of knowledge and practical application be pushed forward together.

SEPARATION OF FOREST HOLDINGS FROM MANUFACTURING

There are no doubt numerous cases of pulp and paper and other wood-manufacturing enterprises of such assured permanence that the owners are justified in engaging in forest management operations in order to provide themselves with a permanent supply of raw material. The assumption that this is universally necessary or desirable is of much the same order as assuming that a meat-packing plant should engage in the stock business. As a matter of fact the business of continuous forest management and the business of manufacturing and selling forest products are very distinct fields requiring wholly different abilities. The great need of a forest business is an outlet for many sorts and sizes of forest material. No one type of manufacturing plant can use all these sorts of material. Therefore to provide every forest property or even the very large properties with complete outlets would multiply plant investments beyond all possibility of their yielding satisfactory earnings. Economical use of capital as well as adequate attention to management details generally limits the forest owner to following his products through the preparation of raw material properly graded for the use of the manufacturers. Under these conditions the forest owner having no absolute demand for a certain annual cut can keep his cuttings to a minimum during periods of low prices and cut more heavily when demand is heavy. Close attention to movement of stumpage prices on each tree size and portion of the stand is one of the chief elements in obtaining the maximum return from a forest property.

PERFECTING STATISTICAL INFORMATION, ETC.

It is generally recognized by economists and business authorities that reliable current information on production, sales orders, inventory, etc., in his industry is an absolute necessity to the modern business manager. The Bureau of the Census and the Forest Service have for many years collected national statistics at 1-year, 5-year, or 10-year intervals. It is hardly to be expected that such statistics can be collected at Government expense more frequently than once a year. For this reason several trade associations collect weekly statistics in their territory. These are not always complete in any given territory, and some territory is not covered. It is essential that the system of collection be perfected and that a liason be arranged between Government and trade-association work in order that complete statistics may be available on a weekly basis, for the country as a whole. By the cooperative application of modern statistical methods relying on properly selected samples this work could be perfected at little increase in expense. This is in the interest of owners, managers, employees, consumers, and all other persons having to do with forest industry or forest products.

OTHER TRADE-ASSOCIATION ACTIVITIES

Forest industries are as a general rule well organized into trade associations. It appears that any steps toward better production control or a better planned and less wasteful operation of the industry must make important use of these associations. The frequent collection of statistics has already been mentioned as one important function of the trade association. Standardization, inspection of products, and sales promotion have long been recognized as important trade-association fields of activity. The associations have also encouraged better business ethics. Additional activities such as regional sales or organization and establishment of production quotas have not been studied sufficiently to warrant any conclusions. Some of these cannot be engaged in without modification of existing laws. It is in accord with American tradition that any such practices should be on the basis of voluntary cooperation.

ORGANIZATION OF FOREST CREDIT FACILITIES

The organization of forest credit facilities is discussed in another section of this report. It is believed that such organization properly worked out under the supervision of the Federal Government can be of considerable assistance in stabilizing the underlying finance of forest ownership and relieving pressure for liquidation. The ultimate aim of such organization should be to bring about a flow of credit capital sufficient, in conjunction with owners' capital, to enable forest owners, forest workers, and forest-products consumers to take full advantage of the great industrial opportunity offered by our forest resources.

REVISION OF FOREST TAXATION

Revised methods of forest taxation are discussed in detail in a report now being prepared by the Forest Taxation Inquiry.

FINAL MEANS TO INSURE CONTINUED PRODUCTIVITY

The measures mentioned in the foregoing virtually exhaust the means by which private forestry can be encouraged and facilitated. Failure of these measures would necessitate resort to more drastic measures. One of these is governmental regulation of the management of forest property. The methods utilized in such governmental regulation in various countries and the limited measures so far adopted in this country are discussed elsewhere in this report. The other and final measure is public ownership and management of the resource to the end that a continuous supply of raw material may be available to the forest industries. It is probable that stability will eventually be obtained by a judicious distribution of private and public management according to the economic and physical conditions present in each locality.

SUMMARY

1. Owing to the almost complete removal of the forest capital from about 40 percent of the privately owned forest land and to very material reduction on an additional 30 percent, less than 280 million acres out of the 396 million acres of privately owned forest land in the United States is capable of being organized into sustained-yield forest properties from which annual returns can be expected immediately.
2. Of this area 127 million acres is in farm woodlands and is managed as part of the farm business. Improved practices are needed on this acreage.
3. Of the remainder about 2,300,000 acres has actually been organized for sustained yield and an additional 15,600,000 acres is being subjected to various measures designed to prolong productivity in some measure. Beyond this, large areas are being partially protected from fire.
4. The liquidation policy applied to private forest lands has resulted in a costly waste of industrial assets. Wherever practicable, this policy should be abandoned in favor of a sustained-yield policy, to save the heavy costs of depletion and other losses.
5. The selection system with short cutting cycles provides in most forests an effective means of preserving and building up growing stock. At the same time in most cases it increases current returns from forest properties.
5. The extent to which forest properties have been liquidated, and the consequent critical state of the growing stock in most regions, call for prompt action placing suitable forest properties under responsible organized permanent management.

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PRIVATELY SUPPORTED AND QUASI-PUBLIC FOREST RESEARCH

By E. H. Frothingham, Director, Appalachian Forest Experiment Station

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In addition to Federal and State research in timber production, utilization, forest entomology, pathology, and other subjects, a considerable amount of forest research is being conducted by privately supported and quasi-public institutions of various kinds. Among these are endowed schools of forestry, university departments of botany, economics, and other sciences, the large research foundations and one or two smaller biological research stations, arboreta and botanical gardens, trade associations, and corporations engaged in the manufacture or treatment of forest products.

While several of these agencies already have, or are preparing, systematic, long-time programs of forest research, others make no pretense of continuity but undertake investigations to meet some special need, or because a forestry subject happens to appeal to the interest and aptitudes of a particular investigator. Hence the investigative subjects are of great variety, some broadly comprehensive or superficial to meet emergency needs, others specific and fundamental within narrow fields to obtain exact knowledge of cause and effect relations.

ENDOWED RESEARCH AT FOREST SCHOOLS

State-supported research at forest schools was discussed in the section "State Accomplishments and Plans." The research here considered includes that at forest schools entirely under private support as well as some endowed work at State institutions. Many endowed universities, including those which have schools of forestry, are carrying on work in botany, zoology, economics, and other subjects, some of which is really forestry or so closely allied or fundamental to it that it can be properly classed as forest research. This is discussed under the next topic, Endowed Forest Research in Other Departments of Universities.

Research in almost all phases of forest management is carried on in connection with instruction and the operation of the Harvard Forest of 2,100 acres, at Petersham, Mass. The staff consists of a director, assistant director, and an instructor, in addition to whom there are usually several graduate students. The part of the investigative program centering around the management of the experimental demonstration forest includes methods of cutting in several forest types, the improvement of inferior or deteriorated stands, thinnings, growth and yield, and artificial forestation. The program also includes some work on forest entomology, studies of light and soils and forest fires, and an investigation of factors influencing the marketing of local timber. The estimated total expenditure for research is between $10,000 and $15,000 a year.

One of the most comprehensive forest research programs at endowed universitites is that of the Yale School of Forestry, and this is supplemented by some work in other departments of the university on closely related subjects. The combined program includes investigations in dendrology, genetics, nursery practice and planting, silviculture, forest management, volume, growth, yield, wood technology, and a group of projects on lumbering. The income from an endowment for forest research is used chiefly for the employment of graduate students. Two or three members of the staff are able to devote large parts of their time to research subjects; one such subject is the investigation of tropical woods. The school plans to relieve the older members of the faculty for further research by the employment of instructors and additional graduate assistants as rapidly as additional endowments become available. The school owns several experimental and demonstration forests in New Hampshire, Vermont, and Connecticut, totaling about 9,000 acres, and utilizes additional areas of several thousand acres. Its research results appear in a series of bulletins, of which 35 have so far been issued. The total estimated present cost of forest research at Yale is between $20,000 and $25,000 a year.

The recently organized department of forestry at Duke University, Durham, N.C., is a graduate institution devoted very largely to forest research, most of which is conducted by the director, assistant director and, at present, two assistants, on the Duke Forest of about 5,000 acres. Six studies of a fundamental nature are now in progress incidental to teaching or administrative work, at a cost for the current year of approximately $3,000.

At the School of Forestry and Conservation, University of Michigan, about $4,000 from an endowment for the promotion of private forestry is annually devoted to the research phases of the subject. There is also a private fellowship in tree physiology amounting to about $500. The $4,500 thus provided for research is in addition to State funds of $5,000 expended on research by the School of Forestry and Conservation.

Two projects supported by industrial fellowships are under way in the Division of Forestry, University of Minnesota. One of these deals with the movement of liquids through wood, the other with pulping problems of aspen. A third project, in forest pathology, is also supported by private funds. The annual cost is about $4,800.

The total expenditure for privately supported forest research at forest schools, allowing for possible incompleteness of the citations, is probably in the neighborhood of $60,000.

ENDOWED FOREST RESEARCH IN OTHER DEPARTMENTS OF UNIVERSITIES

Research in sciences basic to foresty is conducted at many colleges and universities, usually in the departments of botany, zoology, geography, engineering, or economics. At a few universities such work relating closely to forestry is quite continuous; at others it is more or less interrupted and incidental.

At Harvard, the Bussey Institution is doing research in wood anatomy, in its bearing on physiology, pathology, identification, properties, and uses, and is making studies of the cambium in relation to growth and of the bordered pits in relation to the ascent of sap and wood preservation.

Duke University at Durham, N.C., is beginning an active program of research in botany and zoology, on subjects related to forestry. At present 10 projects, 6 botanical and 4 zoological, are under way at a cost of about $4,500.

Cornell University has received an endowment of $10,000 to provide a chair of forest soils. A comprehensive program of forest soil investigations, under direction of a full-time professor of soils, is in progress.

At Yale, Johns Hopkins, Chicago, Stanford, Cincinnati, and other endowed universities research in general plant ecology and physiology frequently includes studies of forest invasion or succession, or of the physiological functions of trees. Lawrence College, Appleton, Wis., maintains an Institute of Paper Chemistry at which research in the chemistry of paper is conducted. At the University of Wisconsin a private fellowship in forest economics, dealing with the forestry aspects of land utilization, has been carried for two years with an expenditure of $1,200 annually. This has now been discontinued, but during the current year about $600 was expended on the project.

Clark University, Worcester, Mass., while not at present engaged in research dealing with forestry, has in the past directed the work of graduate students in studies of the relation of forests to industry in Maine, the geographical factors affecting present forest distribution in Nearctic North America, the invasion and succession of forest types upon the soils of the Massachusetts upland, and a series of localized investigations on the land utilization of a number of upland New England towns, in which the forest played an incidental part.

It is difficult to estimate the expenditures for research relating specifically to forestry and forest products at these institutions, since it forms only a part of the investigative work conducted. A conservative estimate would place the aggregate annual cost of the studies directly pertaining to forestry at $60,000.

FOREST RESEARCH BY ENDOWED RESEARCH INSTITUTIONS

The Carnegie Institute of Washington, chiefly through its division of plant biology, is conducting numerous investigations basic or closely related to forestry. At the Alpine Laboratory, Manitou, Colo., the Coastal Laboratory, Carmel, Calif., and the Desert Laboratory, Tucson, Ariz., studies in plant ecology, activity of woody tissues relative to physiological functions, diurnal and seasonal changes in tree diameters, relation of precipitation to run-off and soil moisture, and various relations and responses of physiological functions to environmental conditions are being made as part of comprehensive investigations relating to the ecology of forest, range, chaparral, and subordinate forest vegetation. Studies of climatic cycles and tree growth, of root development and root functions of the redwood, of photosynthesis and carbohydrate chemistry, and of the cambium and its derivative tissues have also been made. The total expense for research basic or related to timber or range land management, conducted by the Carnegie Institution in 1932, was informally estimated at $75,000.

The Boyce Thompson Institute for Plant Research, Inc., Yonkers, N.Y., is engaged in fundamental research in botany. Problems relating to timber trees form a part of the work, and many of the results obtained in other fields of botany will be of indirect value to forestry by contributing to the understanding of tree functions and growth. The institute has apparatus for the control of all conditions of plant growth on a rather large scale. It is developing a 305-acre arboretum which is being used as an experimental field for problems in forestry and horticulture. Its Southwestern Arboretum, at Superior, Ariz., has been established for the local study of plant problems including tests of native and exotic species. The endowment of the institute is about $8,000,000.

The Mellon Institute of Industrial Research, Pittsburgh, Pa., undertakes some work on forest products as a part of its industrial investigations. For example, it has made studies of box container construction, pulp and paper manufacture, uses for naval stores, etc. Its policy is to undertake investigations, not suggested by industry, but planned within the Institute and directed toward the study of more fundamental scientific problems than those usually investigated for industrial purposes. It is primarily an industrial experiment station, operated in accordance with the Industrial Fellowship System of Dr. Robert Kennedy Duncan.

The Institute of Forest Genetics, Placerville, Calif., established in 1925 as the Eddy Tree Breeding Station, is working on the development, by cross-breeding and selection, of better and more rapidly growing strains of forest trees. Annual expenditures are estimated to be in the neighborhood of $15,000. An endowment to yield an annual income of $50,000 is sought.

The Rocky Mountain Biological Station at Gothic, Colo., conducts 6-week summer courses in zoology, botany, ecology, parasitology, genetics, and other subjects dealing generally with the relationship of plants and animals to their environment and including the forest as an essential factor. Cooperation with the Forest Service by means of a Federal experimental forest is proposed. At Highlands, N.C., a biological research station has recently been established at which much the same character of investigations will doubtless be conducted.

The Tropical Plant Research Foundation, Washington, D.C., which operates on funds for research received from organizations interested in tropical plant products, has conducted some investigations in tropical forestry. Among these is a 4-year survey of tropical American timber resources, including studies of the composition and extent of the important tropical forests, local uses of the more abundant species, and conditions bearing on the possibilities and need for forest culture. The work has included tests made at the University of Michigan to determine the fitness of tropical species for use by wood-working industries in the United States. The institute has also cooperated with the Boyce Thompson Institute and the Department of Botany at Columbia University.

In the field of economics, a number of institutions have done or are doing research bearing, to a greater or less degree, upon forestry. Among these are the National Institute of Public Administration, New York City, which a few years ago made a partial study of forest taxation in New York; the National Industrial Conference Board, New York City, which made a similar investigation in Wisconsin; and the Institute for Economic Research at Chicago, Ill.

The aggregate annual expenditures for research relating to forestry by the institutions in the group above considered is probably in the neighborhood of $180,000.

FOREST RESEARCH AT ARBORETA AND BOTANICAL GARDENS

Arboreta form an important link in the chain of forest research as the means by which trees from widely separate parts of the world may be brought together, tested, and compared to determine their relative merits for timber production, ornamental and other purposes. This comparative study of different tree species and varieties, or of the same species from different climatic regions, brings out in striking contrast important differences which might otherwise easily escape observation—difference in frost hardiness, drought resistance, susceptibility to insect attacks and disease, growth rate, form and quality of the timber, and other characteristics that bear upon the success of forestry. Such studies give a better understanding of the conditions under which the different species can be grown, and often lead to extensions of the geographic range within which they may be safely planted.

Within recent years, other lines of research have further extended the usefulness of arboreta. One such field of great promise is that of genetics, which seeks to develop, through crossbreeding, trees of better quality, straighter grain, more rapid growth, greater resistance to climatic extremes, insects, and disease, or of more certainty and ease of reproduction than the present strains. Other fields in which some arboreta are already carrying on investigations of value to forestry are those of plant physiology and related botanical sciences. The laws of tree growth, reproduction, water conduction, nutrition, etc., and their relation to soil and other environmental conditions, can be studied to excellent advantage in arboreta. Success in timber production and in the use of trees for other purposes requires a full understanding of these laws.

Since many of the results to be obtained in arboreta are applicable only in the climatic regions within which the arboreta are located, there should be arboreta in all such regions. According to figures compiled in 1931[1] there are now 72 active arboreta and botanical gardens in the United States, with five more in prospect. The distribution is very uneven; 12 are in New York, 10 in Pennsylvania, 7 in Ohio, 6 in Massachusetts, and 8 in California. The remaining 29 which are active are scattered among 17 States, the District of Columbia, and Hawaii. These gardens vary a great deal in degree of usefulness for scientific research, and only a few are regularly used for this purpose. Among these few may be mentioned the Arnold Arboretum, Jamaica Plain, Mass.; the New York Botanical Garden, the Bronx, New York City; the Brooklyn Botanic Garden, Brooklyn, N.Y.; the Missouri Botanical Gardens, St. Louis, Mo.; the arboreta of

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[1] Report of the Committee on Botanical Gardens and Arboretums, American Association of Nurserymen. July, 1931.

Boyce Thompson Institute of Plant Research, Yonkers, N.Y., and Superior, Ariz.; and the gardens of the Carnegie Institution at Tucson, Ariz., and Carmel, Calif.

The Arnold Arboretum and the Missouri Botanical Gardens may be cited as illustrations of the capacities of arboreta for forest research. The Arnold Arboretum was established in 1872 for the study and cultivation of all woody plants capable of withstanding the climate of Massachusetts. Until about a few years ago the work was mainly the assembling of trees and other woody plants from all parts of the world, identifying, classifying, and propagating them, exchanging them with other arboreta and nurseries, and building up a library and herbarium. Recently, two research departments have been established, one in pathology, the other in genetics, and special work in dendrology is to be offered to graduate students. The present area of the arboretum is 260 acres, and the site is assured for 1,000 years. There are now about 6,500 species and varieties of trees, shrubs, and vines in the arboretum.

The Missouri Botanical Gardens (Shaw Gardens) were established at St. Louis about 1860. A 1,600-acre extension has been made at Gray Summit, Mo., and a tropical station is maintained in the Panama Canal Zone, on Federal land. Collectors and correspondents are maintained in many parts of the world. Many kinds of research are under way, much of it in taxonomy.

The expenditures of arboreta on research relating to forestry probably amount to about $50,000 a year.

"The establishment of an arboretum", says the report of the Botanic Garden and Arboretum Committee, Robert Pyle, chairman, "is long, slow, and expensive." The report continues:

> Land and ample funds are essential. Capable administration is obviously important. The selection, assembling, and wise arrangement of plant material or tree groups, the laying down of drives, walks, and buildings is but one step. There follows the study of problems of adaptability to climate, the observation and control of plant enemies. Hybridizing and experimental work offer great opportunities. There is, too, the problem of developing the arboretum for the use of the general public, as a living library may be used for information both useful and enjoyable.
>
> The services which an arboretum may render are more important, more varied, and perhaps more intimate in the life of a community than may at first appear. Can this important function in our civilization be cared for better by the agricultural departments of our Federal of State or city governments, by the State agricultural or experimental colleges, as in Texas, or by private and liberally endowed foundations, such as Morton Arboretum or Boyce Thompson Institute?

FOREST RESEARCH BY THE INDUSTRIES

Industrial research in the manufacture and processing of lumber and other forest products was under way at about 200 laboratories in 1931, according to statistics compiled by the National Research Council,[2] and these do not include research by lumber companies and lumber manufacturers associations. Relatively few of these laboratories are concerned exclusively with wood problems. The normal employment on wood-products research is probably in excess of 350 technical workers.

The largest amount of industrial research in forest products is overwhelmingly in pulp and paper. The number of pulp and paper laboratories is listed as 166, of which 58 are owned and operated by pulp and paper companies—35 in the Northeast, 10 in the Lake States, 8 in the Central States, 3 in the South, and 2 in California. Fourteen are credited with 8 or more technical workers apiece, and the total number of technical men normally employed by all these laboratories is probably about 285. Even at present the collective research expenditures throughout the industry are more than $2,000,000 a year, according to the research committee of the American Pulp and Paper Association.

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[2] Bulletin 81 of the National Research Council, "Industrial Research Laboratories of the United States." 1931.

From replies to a questionnaire sent out in 1928 to the larger manufacturing concerns in the United States by the National Research Council, the trend of major emphasis on research by pulp and paper manufacturers is as follows:

	Percent
To reduce production costs	31
To improve quality of product and service	35
To develop new fields of application	23
To develop byproducts or new materials	11

These objectives are those of pulp and paper manufacture rather than timber production. Among them are the standardization of processes in order to obtain the uniform products so important from the commercial point of view, and the development of special kinds of paper. Another is the improvement of the commonly used processes of pulp making. Still another concerns the methods used for recovering the liquors used in the pulping processes and thus avoiding stream pollution. Investigations aimed to make hitherto unused woods available for paper manufacture, or to extend the adaptability of certain species to new uses, are often of far-reaching importance, as in the case of experiments recently started by Georgia in cooperation with the Chemical Foundations, Inc., of New York, to develop the use of southern pines for newsprint.

In the manufacture of wood and fiber-board containers, 17 firms and one association of firms maintain research organizations of one or more technical men, and 18 other firms have box-testing equipment but probably do not devote as much as one half time of one man to research. The research on containers may be considered largely as the application to special problems of principles and methods previously developed by Federal research. Of the 18 larger laboratories, 7 are in the Northeast, 9 in the Central States, and one each in Minnesota and California.

Nine large companies, including the Bell Telephone, du Pont de Nemours, Western Union Telegraph, and American Creosoting companies, have laboratories in which more or less research in wood preservation is under way, but no estimate can be given of the number of men so engaged. Wood-preservation research is confined largely to the manufacturers of preservatives and to users of preserved materials, including telephone and telegraph companies and railroads. Seven companies conduct research on the fireproofing of wood. The du Pont and the Dow Chemical companies are doing some research on sap stain.

Eight organizations are listed as engaged in paint and varnish research related to the use of wood. These include, among others, the Aluminum Co. of America, the Bell Telephone Laboratories, E. I. du Pont de Nemours and Co., and the Institute of Paint and Varnish Research. An equivalent of the time of 10 technical workers is normally engaged in this research. In the glue industry it is difficult to estimate the proportion of the listed research that is directed toward improved quality of wood glues or improved methods of wood gluing. Probably five firms with an average of one technical man each would cover the wood-gluing branch of the industry.

An informal estimate by the National Lumber Manufacturers' Association places the normal collective expenditures for research by this and federated associations at $500,000 a year, under 1929 conditions. Most of this was for forest products research. At the present time the research expenditures by these organizations are undoubtedly much less. The expenditures prior to the depression were partly in the form of small contributions to Federal and State forest products laboratories for investigation of specific problems, but they covered also research at laboratories maintained by some of the associations themselves, notably those of the West Coast Lumbermen's Association and the National Lumber Manufacturers' Association. Subjects studied by the latter in 1930 included heat transmission of wood, air infiltration through frame walls, wood in oil-derrick construction, structural and other tests of wood floors, fire retardant treatment of wood, and fire tests of air-plane hangars, timber columns, partitions, and wood floors.

Not all the research of lumber companies, however, is devoted to forest products. One large company, for example, has made an extensive inventory of its cut-over lands to determine the amount and condition of reproduction that was coming in, and the value of the lands for agriculture and other purposes. Another has made an extensive investigation of selective logging, and has classified the climatic conditions in the localities in which it is collecting seed, for the information and protection of seed purchasers. Various companies have cooperated with the Forest Products Laboratory and with certain States in detailed studies of logging costs and returns designed to determine the sizes of trees that can be economically logged, as well as the advantages of leaving small saw-log trees for further growth. The aggregate of such investigations is not large but is increasing.

Wood enters directly or indirectly into the manufacture of so many additional commodities—automobiles, matches, linoleum, etc.—in connection with which research establishments are maintained by the large producers that it is impossible to determine with any accuracy the amount of research devoted by these industries to wood products.

A conservative estimate of the present aggregate expenditure on forest product research by the industries is $2,500,000.

A few organizations are supporting research relating to game, but relatively little is spent on forestry aspects of this research.

SUMMARY

From the incomplete estimates that have been brought together in the preceding discussion, it would appear that expenditures for endowed, industrial, and other privately supported forest research of all descriptions are about as follows:

Forest schools	$60, 000
Other university departments	60, 000
Foundations	180, 000
Arboreta and botanical gardens	50, 000
Industries	2, 500, 000
Total	2, 850, 000

Nearly 90 percent of the total is for industrial research concerned with forest products, and 70 percent is for pulp and paper research.

PUBLIC REGULATION OF PRIVATE FORESTS

By W. N. Sparhawk, Senior Forest Economist

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INTRODUCTION

The numerous ways in which our forests contribute to the well-being of communities, States, and Nation have been described in preceding sections of this report. They are the source of indispensable raw materials which support great industries and afford means of livelihood to millions of people. They help to conserve water supplies without which our cities and villages, many of our industries, and an important portion of our agriculture could not exist. They help to maintain the navigability of our streams and harbors. They protect our soild from washing away. They ameliorate the climate. They are the home of many kinds of wild life which are useful or afford pleasure to man. In many ways, they promote the health and happiness of our people.

WITH UNRESTRICTED FOREST EXPLOITATION, THE PUBLIC HAS LOST

Among these multiple services of forests, private owners in most cases derive direct personal benefits from only a few. Under the existing system of profit economy, they naturally seek to derive the maximum immediate benefits, without regard to the less tangible public values which are involved. This would not be objectionable if there were no conflict between what individuals conceive to be to their immediate interest and the long-run public welfare.

Unfortunately, such a conflict does exist in the majority of instances. In seeking immediate profit, great injury has been done both to individuals and to the public. Many communities and regions have been impoverished by the devastation of their forests. Millions of acres of fertile land from which the forest cover was removed have been worn out and rendered utterly worthless by erosion. Water supplies have become irregular, streams have been muddied by heavy burdens of silt, and channels have been obstructed, necessitating huge public expenditures to keep them open and to control the ravages of floods. In many places, forest destruction has resulted in excessive depletion of our fish and of upland game and fur-bearers. Burned snags and stumps have replaced the cool shade of green forests along many of our highways, and the beauty of lake shores and river banks has been destroyed.

POSSIBLE REMEDIES

These processes are still going on. Neither the States nor the Nation can afford to let them continue. There are three possible ways of putting an end to them, all of which already have a place in our public policy. These are: (1) Education and persuasion of the private owners, coupled with assistance by the public; (2) public regulation of the practices of private owners; and (3) acquisition of the forests by the public.

PUBLIC OWNERSHIP

The simplest and the surest method would be for the public to take over the forests and manage them as public properties. This is being done on a comparatively small scale. It may be done on a much larger scale in the future. (See section on the "Probable Future Distribution of Forest Land Ownership.") However, acquisition by purchase is likely to be expensive and consequently slow, and judging from past experience, acquisition by gift, exchange, or default is uncertain, unsystematic, and most likely to come about after the forest values have been seriously impaired. It is necessary, therefore, to consider whether other methods may also be effective in protecting the public's interests.

UNDER CONTINUED PRIVATE OWNERSHIP

Policies with respect to public acquisition of forest land will depend to a considerable extent on whether the land will be utilized by private owners in such a manner as to safeguard the public interests. If this could be depended on, public acquisition would be largely unnecessary. Four fifths of our productive forest land is privately owned. Obviously, public acquisition of all of it in the near future is out of the question. The greater portion of it is likely to remain in private ownership, at least for many years. Public welfare requires continued maintenance of forest cover on most of it, and continued production of timber on a very considerable portion.

Experience here and abroad does not indicate that private owners on their own initiative and unassisted will utilize the land for timber growing or even maintain a forest cover to the extent that is desirable or necessary. Their failure to do so results from several causes, including lack of knowledge as to how to use the land effectively for forestry; the belief that other uses will be more profitable; lack of financial resources; lack of assurance that such use will yield a profit, or even a well-founded belief, in many instances, that it will not; desire to liquidate their investment and lack of interest in the land after the timber has been removed.

Public agencies can do much to stimulate private forestry through research and education, and demonstration of forestry practices. They can do more through various measures of public cooperation and assistance, as discussed in other sections of this report. However, cooperation which is optional with the forest owners, or public assistance which is not accompanied by the obligation to handle the forest conservatively, has yielded almost negligible results so far as the adoption of good forest practices is concerned. Even though the public pays a considerable portion of the cost of fire protection in many States, the owners of less than 6 percent of the privately owned forest are making a conscious effort to keep it productive. Judging from results thus far, there is little ground for confidence that the major portion of our privately owned forest land will be used properly unless there is some degree of public control. Such control is the rule, at least for those classes of land most vitally affecting the public interest, in nearly all except the more backward countries.

PUBLIC REGULATION OF PRIVATE PROPERTY IS NOT UNUSUAL

The right of the public to regulate commerce and the various forms of privately owned utilities which serve the public is generally recognized in the United States as well as in other countries. Public restriction on the use of forest land, however, has been opposed on the ground that it involves infringement upon the rights of private property and radical or even revolutionary extension of the sphere of government. Consideration of the facts shows that that is not the case. Such objections overlook the historical facts as to the nature of private property in land and the functions of government. Title to landed property in the United States, as in England, and in most, if not all other countries, originated in a grant from the government. In earlier times, the recipients or their successors were obliged to render military or other service to the King or to the government as a condition of holding the land. Even today, in the United States, private ownership of land is not absolute. Land owners who fail to contribute to the support of government through taxation forfeit their land to the Government. Many owners of cut-over land have been doing this in recent years. Both the State and Federal Governments retain, and frequently exercise, the right to expropriate any private land that is needed for public purposes, and they even delegate similar authority to certain classes of private corporations, such as railroads, where such expropriation is in the public interest.

A major object of organized government, whatever its form, is to control or restrict, so far as the public interest may require, the actions of individuals that may affect the welfare of other individuals or of the group as a whole. Absence of such control would mean anarchy. The character and extent of governmental restriction or control vary with the political philosophy and the stage of economic development of a people. As social organization and economic relations become more complex, control becomes desirable with respect to matters over which it was not desirable at earlier periods. With increasing density of population and increasing need for efficient utilization of limited natural resources, the necessity of social control over such use increases both to prevent harm to individuals, and also to insure the present and future welfare of society as a whole. From the earliest times, governments have concerned themselves, in varying degree, with bringing about that utilization of their land and other resources which would promote the general welfare.

FARM LAND

With agricultural land, most countries have sought to accomplish this primarily through distributing it to individual owners and insuring more or less stability of ownership. The owners have enjoyed practically absolute freedom to use their land as they saw fit, although governments have not hesitated to exert rather strict control over certain phases of the use of private farm property in emergencies when such action was necessary to protect the interests of the public. Examples of such governmental interference in this country are the campaigns against foot and mouth disease, bovine tuberculosis, cattle tick, corn borer, and Mediterranean fruit fly; the requirement in some wheat-growing States that barberries be eradicated; the prohibitions in several States against planting currants and gooseberries near white pine forests and against growing red cedars near apple orchards (Virginia); the requirement in many States that livestock be kept under fence; and the obligation of property owners to clean up noxious weeds so as to prevent their spread to neighboring land.

In the past, the economic factors and conditions governing the production of agricultural crops have been such that the owners had an incentive to utilize their land generally in the public interest. The present alarming situation with respect to erosion in certain portions of the United States demonstrates that it has not always been so utilized. In recent years the economic situation of agriculture has changed until there is some reason to believe that individual self-interest alone, at least in the present stage of enlightenment, is no longer adequate to safeguard the public interests in the utilization of farm land.

Recognizing this, governments have endeavored to promote the voluntary adoption of improved methods through research, education, demonstration, and other forms of assistance. Much has been accomplished in this way, but uncoordinated action by individuals does not seem to be enough. The need for some degree of public or quasi-public control over agricultural production or marketing is coming to be recognized in many countries. Russia has her 5-year plan and State farms; Italy has her "battle of the wheat"; we have our Federal Farm Board, to say nothing of the laws proposed to restrict cotton production in several States. A number of countries prohibit or restrict the agricultural use of land that is liable to become seriously eroded and thus cause damage to other property or to the public interests.

MINERALS

The development of mineral resources also has generally been left to private initiative in most countries, except for restrictions designed to safeguard the workers. An important exception in this country is the Federal law restricting hydraulic mining in California in the interest of navigation. (U.S. Stat.L., vol. 27, p. 507.) Mining being strictly an extractive enterprise and highly speculative, rapidity of turnover has been encouraged and great waste of the resources has resulted. Many of the mineral industries have now reached a point where they themselves recognize the need for some form of group control, either by the public or through group cooperation of one kind or another, in order to regulate output and conserve the resource. Examples in the United States are the coal, petroleum, and copper industries.

WILD LIFE

The individual States, and the Federal Government in the case of migratory birds, have retained control over the exploitation of wild animal life, even though most of it breeds and lives on privately owned land. Moreover, large expenditures of public money have been made and are still being made to conserve and propagate our fish, game, and other wild life resources.

URBAN LAND

Many public restrictions on the use of urban land are so obviously necessary and of such long standing that they are accepted by most people without question. In this class are building codes, fire regulations, sanitary codes, and the like. Most, if not all of them, are based on the principle that an owner may not use his property in such a manner as to harm or threaten harm to his neighbor or to the community as a whole. Many newer restrictions, typified by the various zoning laws, that have grown up within comparatively recent years carry this principle even farther, but generally have not been considered unreasonable infringements on private property rights.

WATER RESOURCES

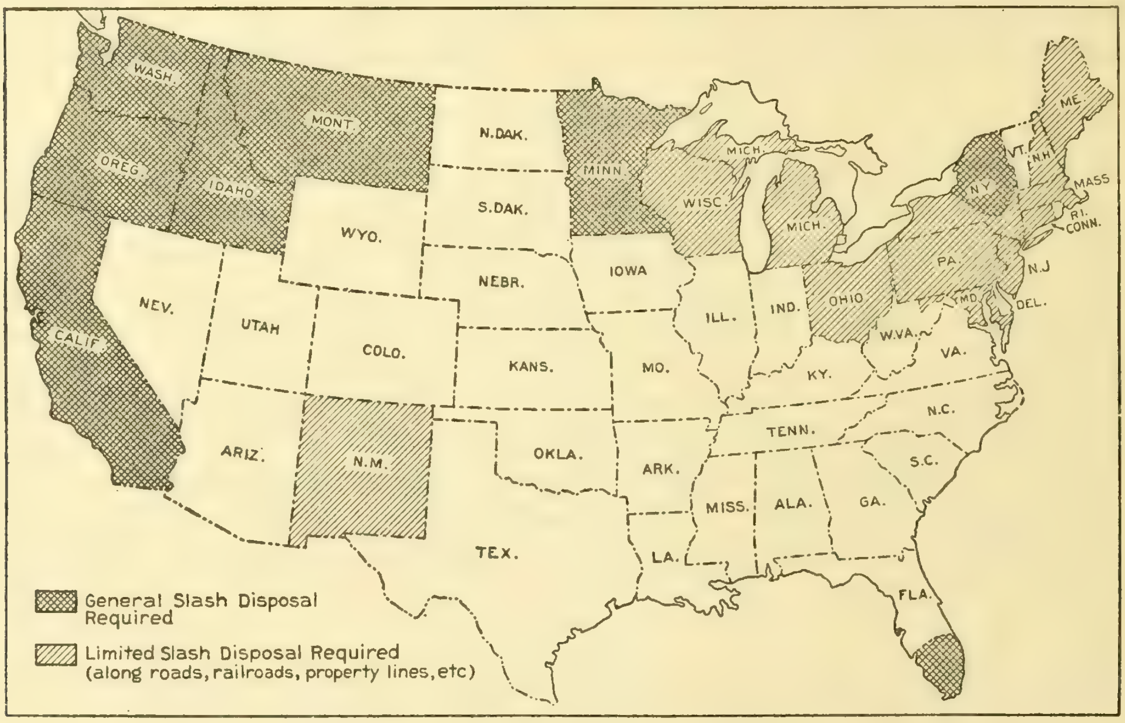
The private use of water resources, even though the stream originates on private land, is subject to a greater or less degree of public control by most States, and in the case of navigable streams by the Federal Government, for such purposes as maintaining navigation, preventing waste of irrigation water, preventing damage to owners of property down stream from dams, preventing pollution of domestic water supplies or of fishing streams, etc. In a few instances the public has gone a step farther and regulated the use of land bordering the streams or on their headwaters, so far as might be necessary to accomplish the above purposes. This has been done, for instance, under the law regulating hydraulic mining in California, previously mentioned.

FORESTS

Individual owners have not felt the same incentive to handle forests for continuous production as in the case of farm lands. As with mines, they have deemed it more advantageous to exploit the timber as quickly as possible, and leave the regeneration of the forests to chance. This has resulted largely from the long-time nature of forest crops and the interchangeability of timber capital and timber product. It has been the common experience of all civilized countries that unguided, voluntary action by private owners will not assure such use of forests as will guarantee their perpetuation or safeguard the interests of the public. Public control over the use of private forests is a live question all over the world. In recent years it has become increasingly evident in the United States that unrestricted freedom of individual action is leading not only to waste of a great natural resource, despoliation of forest lands and lasting injury to the general welfare, but also to the ruin of the lumber and other forest industries themselves.

EXISTING RESTRICTIONS ON FOREST OWNERS IN THE UNITED STATES

As a matter of fact, some aspects of forest-land use by private owners are already subject to a considerable degree of public regulation in the United States. So far, the Federal Government has not undertaken such regulation, although, of course, the various Federal laws relating to the organization and control of business in general affect forest use indirectly. Practically all of the individual States, however, have adopted legislation designed not only to protect forest property from damage by others than the owners, but also in some degree to prevent an owner from using his land so as to cause direct injury to others. These restrictions have to do mainly with the prevention, suppression, and use of fire so that it cannot spread to another's property. No attempt has been made to require such management as will avoid less direct injury to others, through erosion, silting, or irregular stream flow. Nor, with a few minor exceptions, have the States undertaken to prevent an owner from damaging or destroying his own forest, or to require him to keep his forest land productive, or to preserve esthetic or recreational values for the benefit of the public.


WASH.
MONT.
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CALIF.
KANS.
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ARIZ.
N.M.
OKLA.
ARK.
TENN.
N.C.
S.C.
MISS.
ALA.
GA.
TEX.
LA.
FLA.
▦ General Slash Disposal Required
▨ Limited Slash Disposal Required (along roads, railroads, property lines, etc)

FIGURE 1.—States requiring slash disposal.

The various State regulatory measures deal with the following subjects: Control of fire, control of insect pests, control of tree diseases, silvicultural or other measures designed to maintain the productivity of forest land.

CONTROL OF FIRE

The laws of every State restrict the use of fire by owners or operators of forest or woodland or impose requirements designed to prevent the spread of fire to the property of others. These restrictions and requirements vary widely in scope.

REDUCTION OF FIRE HAZARD

Regulations with this purpose are chiefly in connection with logging operations. California, Oregon, Washington, Minnesota, New Jersey, and Florida (in the Everglades only) provide that any dangerous slash or inflammable debris (as determined by the State forester or equivalent agency) must be disposed of by the owner, or at his expense, in a manner approved by the State forester. In these States it is not necessary that the debris be the result of the owner's operations. Idaho, Montana, and Pennsylvania require that slash resulting from logging operations must be disposed of as required by the State forester or fire warden. New York requires the lopping of tops over 3 inches in diameter within the "fire towns." Thirteen States have special requirements for the removal of slash along highways and railroad rights of way. (See fig. 1.) In Maine, Minnesota, New Mexico, and New Hampshire slash must be removed from strips of specified width along the boundaries of adjacent property; in Wisconsin along the boundaries of county forests, and in Minnesota along lake shores.

In Oregon the operator must fell snags not only near engine settings but also along property lines and near areas of reproduction. In Washington the State forester may require felling of snags on any part of the operation where he considers that they constitute a fire hazard.

In 23 States, logging locomotives and stationary engines (unless they burn oil), and in some instances portable and other mills, must be equipped with efficient spark arresters and other devices to prevent the start of fires. Ten of these States require that cleared lines be maintained along logging railroads and around engine and mill settings, in order to prevent fires from spreading.

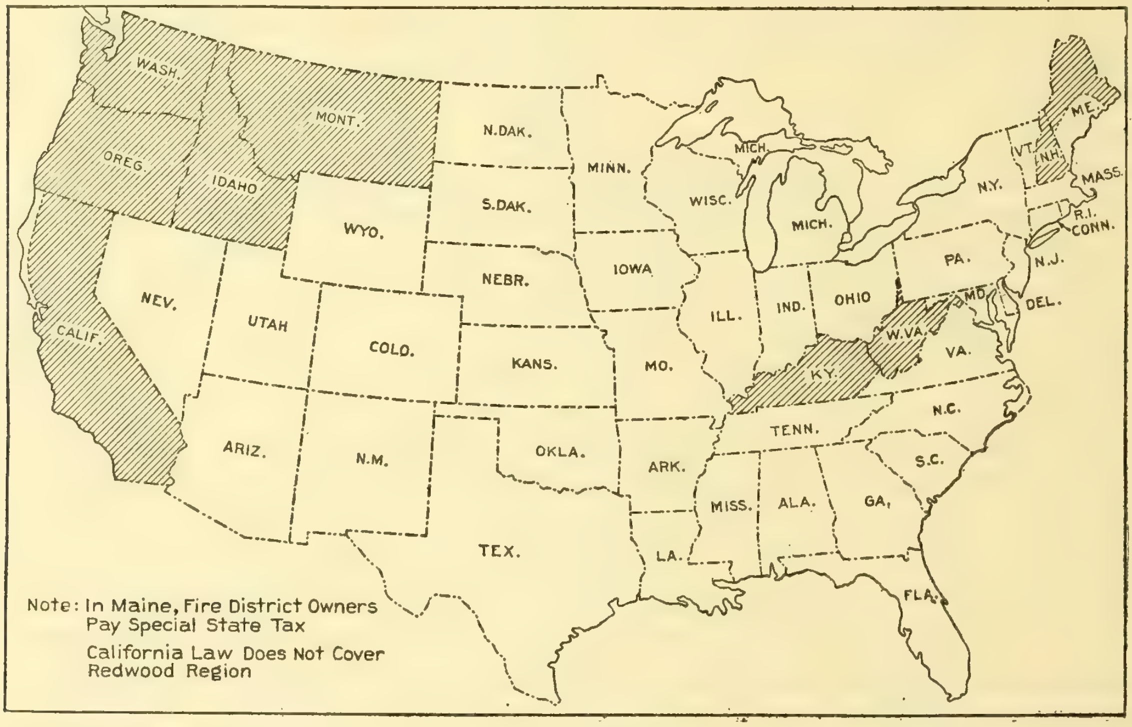
Chiefly in order to facilitate inspection and enforcement of slash disposal and similar requirements, several States provide that owners or operators must report intended cuttings and new set-ups of portable mills. For example, Maine requires operators of portable mills to obtain licenses, which may be suspended during dry periods. In New Hampshire portable mills must be registered with the State forester and must get a permit before operating in each location. Massachusetts provides that portable mills cutting over 10,000 board feet at a setting must notify the State forester as to the location, size of the lot, and the approximate dates of operating. Minnesota requires that the State forester be notified before any timber is cut in a forest or wild land area (except in clearing agricultural land or to cut one's own firewood), and that a notice be posted on the land giving the legal description of the land to be cut over and naming the person who will be responsible for disposal of the slash. New Hampshire requires advance notice before pine is cut, with information as to the name of the owner and the location and size of the lot. Timber owners and sawmill operators are also obliged to report the quantity of timber cut each year. In Rhode Island, timber owners must register with the State Bureau of Forestry before cutting for other than domestic use.

USE OF FIRE

Under the laws of practically all of the States it is a misdemeanor to let fire burn on one's own land unless it is kept from escaping and damaging the property of another. (In Nevada this is a felony.) In most of the States, the person responsible for the fire not only is liable for damages but may also be punished by fines, imprisonment, or both.

The laws of 32 States contain some sort of restriction on the burning of slash, brush, grass, or other material on one's own land. Thirteen

States require that persons burning over their land must give advance notice to adjoining owners; and 7 of these and 6 others require specifically that "all due precautions" must be taken to prevent the spread of fire to other lands. Seven States require that fire lines be cleared around the areas where the burning is to be done. In 16 States, permission of a fire warden or other public official must be obtained before an owner may burn brush, etc., on his own land, at least during the danger season; two other States require similar permits in certain districts (Florida in the Everglades and Pennsylvania on gas and oil lands). Four States (New Hampshire, New York, Rhode Island,and Pennsylvania in the gas and oil districts) require that a warden or someone designated to supervise the burning be present, unless there is no danger of the fire spreading.



Note: In Maine, Fire District Owners Pay Special State Tax
California Law Does Not Cover Redwood Region

FIGURE 2.—States requiring owners to provide fire protection or to support protective organizations.

FIRE PATROL AND SUPPRESSION

California (except in the redwoods), Idaho, Kentucky, Montana, Oregon, Washington, and West Virginia require forest owners to provide a patrol and suppression organization approved by the State forester or corresponding official. (Fig. 2.) An owner may maintain his own organization, or he may meet the requirements through membership in and support of a recognized association which provides such protection. New Hampshire has a similar provision for holdings of more than 1,000 acres. In California, Washington, and Oregon logging engines must also be equipped with pumps, hose, and fire-fighting tools, and all snags within a specified radius of the setting must be felled. In addition, Washington requires a patrol of logging railroads following all trains. Several other States provide that the owner must make every effort to suppress fires on his own land, and that if he fails to do so the State will do it at his expense. In Maine, the State provides protection in the forest district, but collects the costs from the owners in the form of a special tax. In Vermont, towns may assess all owners of unoccupied or uninclosed land (containing inflammable material) up to 5 cents an acre to cover costs of fire fighting (on any land), unless such owners have, during the preceding year, provided adequate protection for their land.

CONTROL OF INSECT PESTS

In a very few States, landowners are required to assist in preventing or checking damage by forest insects. California and Oregon require an owner to notify the State forester of any serious infestation by pine beetles or other insect pests harmful to timber, and also to take steps toward controlling such infestation and preventing its spread. These States also provide for the creation of control districts in which all owners must cooperate provided 60 percent of the owners request it. In Massachusetts, an owner must give notice of an infestation by gypsy or browntail moths and must destroy the eggs and nests of these moths, of tent caterpillars, of leopard moths, of elm beetles, or of "any other tree or shrub destroying pest." The State is obliged to undertake the suppression of such infestations, but may assess the costs against the landowners. In Vermont, the commissioner of agriculture may order an owner to destroy pests, including gypsy and browntail moths "or any other threatening and unusual insect pest found to be unduly injuring vegetable growth." In New York, the conservation department may establish barrier zones and within them destroy such trees and other vegetation as may be necessary to check the spread of gypsy moths.

CONTROL OF TREE DISEASES

Legislation for the control of tree diseases is found in the white pine region of the Northeast and the Lake States. In Maine the forest commissioner, in New Hampshire the State forester, in Michigan the commissioner of agriculture, and in Minnesota the commissioner of forestry may designate areas within which blister-rust control is advisable, and in these areas owners must carry out control measures as ordered. Infected pines and Ribes (currants and gooseberries) are declared public nuisances.

In New Hampshire, Michigan, and Minnesota, an owner may not plant pine or Ribes in the designated areas without a permit. In New York and Michigan black currant is declared a public nuisance, but other currants may be grown within districts designated as fruit-growing districts. Within these districts the eradication of five-needled pines may be required and such pines may not be planted without a permit. Elsewhere, if protective measures against blister-rust have been adopted, owners must eradicate Ribes within 900 feet of pine (in New York). In Vermont the commissioner of agriculture may order owners to destroy host plants and such pests or fungous diseases as he may specify. Such plants may not be replaced until all danger of spread of the disease is past. Planting of black currants is prohibited in Connecticut. In Rhode Island, the board of agriculture is authorized to make regulations regarding the planting of pines and currant bushes.

SILVICULTURAL REQUIREMENTS AND REGULATION OF CUTTING

Only two States have adopted compulsory legislation designed to prevent an operator from denuding his own land by cutting. Louisiana requires an owner or operator cutting timber or bleeding trees for turpentine to leave standing and unbled an average of two seed trees per acre of the kind cut or bled and at least 10 inches in diameter at breast height, on each 10 acres. In New Hampshire, a person cutting pine must leave on every acre (where pine constitutes 75 percent or more of the stand) at least one 10-inch wind-firm pine tree, capable of bearing an abundance of cones. The Mississippi law provides that owners or operators cutting timber or turpentining shall be "encouraged" to leave standing or unbled an average of one seed tree per acre. Nothing is said as to how the encouragement shall be brought about.

A few States provide for a certain degree of control over the time, method, and extent of cutting where the owner has been given a quid pro quo in the form of tax concessions (fig. 3). In the main, this control is optional with forest owners, for they do not become subject to it unless they apply to have their lands classified under the tax laws.[1] These forests are classified under various designations, such as "reforestation lands" (Oregon, Idaho, Washington), "forest crop lands" (Wisconsin), "forest plantations" or "native forest lands" (Indiana), "forest lands" (Ohio, Connecticut), "forest reservations" (Iowa), "forested or reforested lands" (New York), "forest, game, fish, or recreation reserves" (Virginia), "young timber lands" (Vermont), "classified forest lands" (New Hampshire, Massachusetts), "forestry reserves" (Kentucky), "private forest reservations" and "commercial forest reserves" (Michigan), "commercial forest plantations" (Delaware), and "axuiliary forests" (Minnesota, Pennsylva-

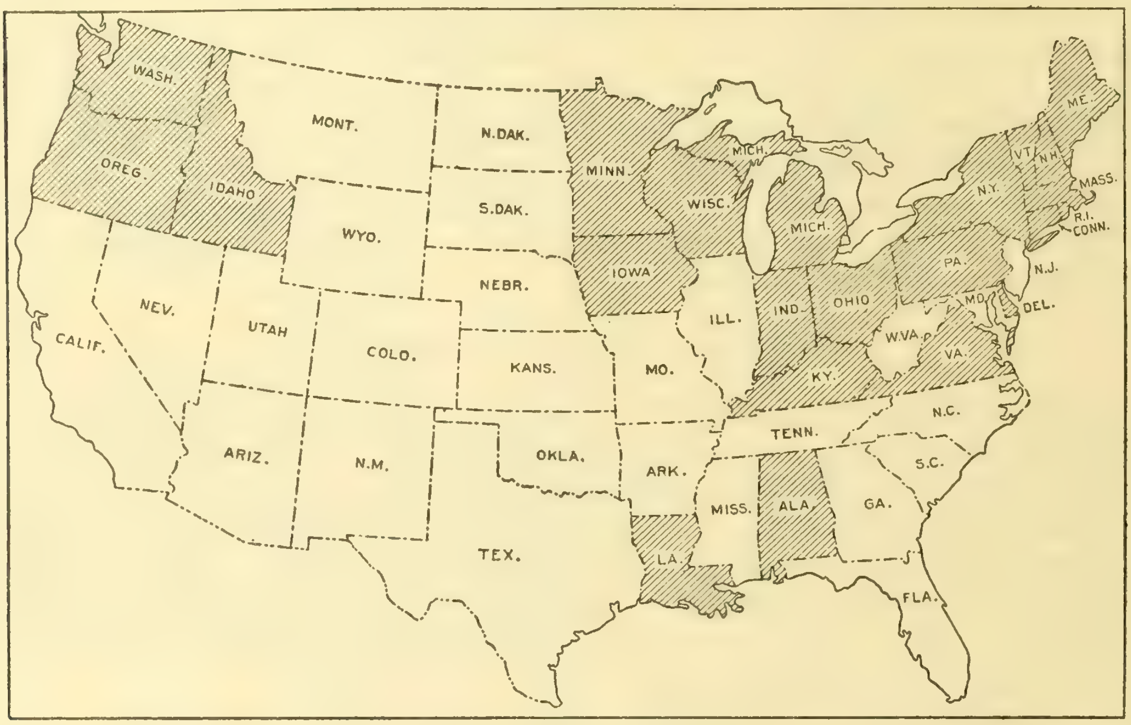


FIGURE 3.—States providing for some degree of public control over classified or "auxiliary" forests.

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[1] Information regarding control over classified forests is based largely on "Digest of forest tax laws in the United States in effect Jan. 1, 1932," Progress Report of Forest Taxation Inquiry, No. 16 (mimeographed).

nia, Maine, Alabama). In some States the owners are merely required to report the quantity of timber cut, as a basis for computing the yield or severance tax to be paid; in other States they are subject to restriction on methods of cutting or forest management.

In Alabama, timber on auxiliary forests may be cut, turpentined, or otherwise utilized only under permit and in accordance with rules formulated by the forestry commission. In Delaware, timber (except dead and injured trees) may not be removed without the approval of the State forestry department. In Idaho, the property must be managed in compliance with the law regarding fire protection and slash disposal, and in compliance with such reasonable regulations as the board of forestry may prescribe for the care of the forests, cutting and removal of timber, and use of the forage. Before cutting any forest products, the owner must give 30 days' notice to the State board of forestry. In Iowa, not more than one fifth of the number of trees on a "forest reservation" may be removed in any one year. In Kentucky, the "forestry reserves" are leased by the State, which controls cutting on them. In Louisiana, classified forests must be maintained in a growing and thrifty condition, must be protected from fire, so far as practicable, and must be grown in accordance with rules laid down by the commissioner of conservation and under his supervision.

In Michigan an owner may cut merchantable forest products only with the permission of the department of conservation. In Minnesota he must manage the forest for the production of merchantable timber under a detailed working plan prepared by the commissioner of forestry in collaboration with the chief of the forestry division of the State university. Only timber designated by the commissioner may be cut. New Hampshire requires merely that the land be kept stocked with trees sufficient to promise a prospective average yield of 25,000 board feet per acre. In New York forests must be cut according to the principles of practical forest management as directed by the conservation commission, and may be thinned with the commission's approval. Ohio requires classified forests to be given reasonable protection and to be cared for and managed according to regulations of the State forester. Rhode Island requires a working plan, which must be approved by the State commissioner of forestry.

In Oregon classified land under contract is to be held for the growing of forest crops upon terms and conditions required by the board of forestry. Harvesting of timber, bark, forage, or other product without permission of the State board of forestry is prohibited. In Pennsylvania auxiliary forests must be cared for and may be thinned under the direction of the department of forests and waters, which also is to prescribe methods of cutting merchantable timber and designate the trees to be cut. In Vermont cutting must not be done in such a way that "proper forest conditions are not maintained", and the local assessors must be notified in advance of cutting. In Virginia, where the land is leased to the State, the State forester controls the management of the land and the method and time of cutting timber. In Washington timber may be cut only with the permission of the State forest board, and cutting must be done and the land reforested and protected in accordance with regulations prescribed by the board. In Wisconsin an owner of classified land must notify the conservation commission and the tax commission in advance of cutting.

Five States seek to prevent the exemption of mature timber by providing that unless it is cut the land will cease to be classified. In Massachusetts the stand must not exceed (for more than 2 years) an average of 25,000 board feet of softwoods or 10,000 feet of hardwoods; in New York the limits are 40,000 and 20,000 feet, respectively. New Hampshire specifies a maximum of 25,000 feet, regardless of species, and in Vermont the timber must be cut when the "listers" (assessors) consider it mature. California provides that a special board shall determine when timber is mature. If a considerable area of forest should be classified, these limitations might in some instances be a handicap to rational forest management. They were adopted presumably for the purpose of heading off the opposition of nonforest-owning taxpayers.

In Connecticut, Iowa, Indiana, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Ohio, Pennsylvania, Vermont, and Washington, the land must be kept stocked with trees of valuable species, and planting may be required unless the land restocks naturally after cutting. In Connecticut, Iowa, and Indiana grazing of livestock is forbidden in classified forests. In Michigan (wood lots) it is subject to restriction, and pasturage which is detrimental to the trees is forbidden in Vermont. In Delaware, the owner must take proper precautions against damage by fire, grazing, or otherwise.

EFFECTIVENESS OF EXISTING RESTRICTIVE LEGISLATION

On the whole, existing laws designed to regulate the handling of private forests are not particularly effective in most of the States. The general restrictions on the use of fire, including such requirements as burning permits, closed seasons, use of due precaution, spark arresters, and precautionary measures in connection with logging operations, are fairly well enforced in most of the Northeastern, Northwestern and Lake States. In several of these States enforcement is spotty, depending upon the individual warden. In most of the Southern and Central States, little attempt is made to enforce the forest fire laws.

Some but not all of the States having slash disposal laws enforce them fairly well as far as slash along highways and railroads is concerned. Laws providing for general slash disposal have proved harder to enforce, and their observance leaves much to be desired, except perhaps in Washington and Oregon. Even there, there is considerable difference of opinion as to whether the methods employed produce the best results. Compulsory patrol laws have proved effective in the three Pacific Coast States, but have not been thoroughly enforced elsewhere. Legislation for the control of pine blister-rust is fairly well enforced in the States to which it applies. The seed-tree laws of New Hampshire and Louisiana are not strictly enforced, and probably would not be particularly effective if they were.

Very little information is available as to the application of public regulation on the forests which have been listed under the special tax laws of various States. However, less than 1,000,000 acres have been put under the law in those States which provide for some control over listed lands. At the most, only 2 percent of the privately owned forest land in any State has been listed. It is evident that optional regulation under the quid pro quo principle of existing laws is not contributing very much toward the solution of our forest problem.

PUBLIC CONTROL OVER PRIVATE FORESTS IN OTHER COUNTRIES

Except for earlier restrictions on hunting, there was very little public interference with the management of private forests in Europe until early in the sixteenth century. At that time wood was still the principal building material and the universal fuel. Populations and industries were growing and with them the necessity for adequate timber supplies. Long-distance transportation of wood was possible only by water. The accessible forests in many regions were becoming badly depleted. It was natural, therefore, that governments should feel concerned over the prospects of a timber shortage and should take steps to forestall it. Between 1500 and 1789 several of them, including France, most of the German States, and Russia, undertook to prevent further destruction of the privately owned as well as the public forests. Many of the forest ordinances of this period forbade owners to clear their forests or even to cut timber without permission of the authorities, and in some instances it was required that government foresters mark the timber before cutting.

These laws were not always strictly enforced, and finally, under the influence of the French Revolution and the doctrines of Adam Smith, practically all of them were repealed or fell into disuse. For several decades thereafter, owners were allowed to manage their forests practically without restriction. Devastation was accelerated, but the development of railroad and other transportation, the increasing use of coal, and the growth of international trade made the danger of a timber famine seem remote.

It was not long, however, before widespread devastation of forests was seen to have other results of even greater public concern than the shortage of a useful commodity. Disastrous floods in many European countries, accompanied by great property damage and loss of life, were attributed to the destruction of the mountain forests. Maintenance of the protective function of the forests, rather than the prevention of a timber shortage, was put forth as a reason for state restriction on the management of private forests. Most of the restrictive legislation during the past century had this as its principal object. France incorporated such restrictions in her Forest Code of 1827, Austria and Bavaria followed in 1852, Prussia in 1875, Italy in 1877, Wurttemberg in 1879, Russia in 1888, Norway in 1893, Sweden in 1903, and Spain in 1908. In 1874, following a series of flood disasters, the Federal Government of Switzerland was given authority to supervise the management of mountain forests. In Japan, heavy flood damages extending over several years led to the adoption in 1882 of legislation restricting the use of forests.[2]

In most countries these laws applied only to a comparatively small proportion of the privately owned forests. There was little or no control over the remainder until after 1900. Even in Germany before the World War, 68 percent of the private forests were free from any state supervision.

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[2] Fernow, B. E., A Brief History of Forestry. 506 p. Cambridge, Mass., 1911. See also Schwappach, Adam, Forstgeschichte, ch. XVII in Handbuch der Forstwissenschaft, ed. 4, bd. 4. Tübingen, 1927.

Since 1900, and particularly since the war, the scope of public control has been greatly broadened in some countries, and extension of control is being urged in most of the others. The maintenance of timber supplies has again become a prominent factor in the legislation of many countries. The fear of a general timber famine, to be sure, has not played such a prominent role as it did in the earlier legislation. Post-war efforts to build up sustained timber production arise partly from the growing spirit of nationalism which makes each country desire to be as nearly self-sufficient as possible. In many countries the movement is based also to a considerable extent on the economic necessity of reducing unfavorable trade balances, and of utilizing the land so as to afford employment to as many persons as possible.

So far as information is available, the essential provisions for public control over private forests in foreign countries are summarized in the following pages.

Unfortunately, satisfactory information is not available as to the effectiveness of these control measures. In some countries, existing legislation is too recent for its results to be apparent. This is particularly true of those countries where it involves radical changes from former methods. In other countries, the principles of sound forest management are well understood and have long been practiced by many forest owners, especially on the large holdings. Even with these, however, the break with old traditions, the dissolution of family estates, and the changed political and economic conditions in general have recently tended to weaken the position of forestry. This has been partly responsible for recent agitation for more restrictive legislation in several countries.

Public control is probably most effective in Switzerland, where there are almost no large private commercial forests and where practically everyone realizes the necessity of maintaining a forest cover for protective purposes. In France and Germany, the various proposals for new and more restrictive laws indicate that existing legislation is believed to be inadequate. In Norway, Sweden, and Finland the laws are generally effective. In those countries control is thoroughly decentralized, and forest owners have a voice in it. Most of the large holdings were already managed along sound lines before regulatory laws were passed. Moreover, forests are so important a factor in the economic life of all three countries that their importance is well understood by everyone.

ARGENTINA[3]

Upon completion of the requisite exploration and surveys, the Argentine congress is to be asked to provide for expropriation of lands classified by the forest service (Inspection General of National Forests) as of public utility, including forests which affect the topography of mountains and slopes, help to prevent erosion of soil in ravines and torrents, protect springs and streams in general, or help to stabilize maritime dunes and prevent erosion of shores.

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[3] Decreto reglamentando la explotacion de bosques y yerbales (Presidential decree of Oct. 4, 1906, on exploitation of forests). Fablet, Luis E., and Brebbia, Carlos, "Monografia forestal de la Republica Argentina." In Actes Congrès International de Sylviculture, vol. 2, p. 295–327. Rome, 1926.

Meanwhile, there is no public control over private forests except upon application by the owners and approval by the Department of Agriculture. Such forests are to be protected by the State, and may be cut or otherwise exploited only as authorized by the executive (i. e., the forest service).

In the province of Tucuman, the cutting of trees in a 100-meter belt along streams is prohibited, as is the destruction of groves in pasture lands.

AUSTRIA [4]

Two thirds of the forest area of Austria is privately owned. About two thirds of this land is in small tracts of less than 100 hectares (250 acres) owned mostly by farmers. Forest land may not be cleared for other use without the permission of the local district authorities. No forest may be devastated so as to make further timber production difficult or impossible. Freshly cut-over land must be restocked within 5 years; a longer period is allowed only in special cases. Older bare land must be reforested within one rotation period. Advance notice must be given before making a clear cutting of more than 1¼ acres (½ hectare) and the authorities may impose certain requirements as to time of cutting, reforestation, etc.

A forest may not be handled in such a way as to expose a neighboring forest to wind damage. On light soils that are easily blown, and on high mountains, clear cutting only in narrow strips or gradual thinning is permitted, and only selection cutting is allowed in forests near timber line. Disturbing of the soil must be avoided on the banks of large streams and in places where there is danger of landslides.

Grazing is forbidden in places where it will damage or prevent reproduction of the forest, and may in no case be in excess of the carrying capacity of the range. Herders must be employed unless there are other effective ways of keeping stock off reproduction areas. Gathering of forest litter is also subject to certain restrictions.

Expert foresters approved by the Government must be employed for tracts above a specified size, which depends on local conditions. Owners must notify the local authorities of the presence of insect pests which threaten other forests, and the owners of all forests which are endangered by such pests must cooperate in control measures.

Where the safety of persons or of public or private property requires special treatment of the forest as a protection against rock-slides, avalanches, washing of the soil, etc., the area may be designated as protection or "ban" forest. This is to be done by a commission, assisted by experts, upon the application of a commune or other interested party, or upon the recommendation of public officials. Protection forests are to be managed by competent persons employed for the purpose, in accordance with rules prescribed by the commission.

Under a special law for regulation of torrents (1884), the interested parties are obliged to contribute toward costs of forest planting and other corrective work, which is carried out by the forest protective organization. The State and the provinces have borne about 70 percent of these costs.

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[4] Schindler, Karl, Die Forst-und Jagdgesetze der Oesterreichischer Monarchie. 465 p. Wien, 1866. Fernow, B. E., A Brief History of Forestry, p. 163–166. Cambridge, Mass., 1911. Weber, H., Forstpolitik. ch. XIX in Handbuch der Forstwissenschaft, ed. 4, bd. 4, p. 369. Tübingen, 1927.

BELGIUM[5]

Nearly 60 percent of the forest area of Belgium is privately owned. Most of the holdings are small. Under the law enacted in 1931, which takes the place of a similar provisional law of 1921, the Minister of Agriculture may forbid abnormal or excessive cutting of any woodland which is of special public importance because it serves to protect the soil on mountains and slopes, to prevent erosion by streams, to regularize the flow of streams and springs, to stabilize dunes and coasts, or because it is necessary for purposes of the national defense or public health. Cutting that removes more than half the volume of timber in high forest, or that leaves less than 75 cubic meters per hectare (about 1,000 cubic feet per acre), and cutting that removes more than 60 percent or leaves less than 25 cubic meters in coppice with-standards, is considered excessive. Broad-leaved forests of less than 10 hectares (25 acres) and coniferous forests of less than 25 hectares, as well as coppice, and coppice-with-standards where the overstory contains less than 25 cubic meters per hectare, are exempt from control.

The Belgian law differs from the French law in that a forest owner is not required to give advance notice of an intended cutting, and the restriction is not limited to clear cutting but also covers abusive cutting that is likely to lead to the same result. The Belgian law also provides that the minister may authorize excessive cutting, provided the owner will agree to undertake certain measures, such as replanting the same or an equivalent area within a specified time.

A forest owner may appeal from a decision by the minister to a commission consisting of a magistrate appointed by the King and two persons named by the Superior Forestry Council.

Another law provides for prohibiting the destruction of forests of special historic or scenic significance.

BRAZIL[6]

Owners of forest land in Brazil may apply to have their forests classified, especially in case of protection forests which serve to regularize streams, prevent erosion, promote the public health or national defense, or which are natural beauty spots or wild-life preserves. These forests must be managed in a manner approved by the forest service, as regards both timber exploitation and grazing. The Federal Government, in cooperation with local governments, is to grant special favors to compensate for the restriction. These favors may include assistance in building roads, police protection, and subsidies for planting.

BULGARIA

Less than one fifth of the forest land of Bulgaria is in private ownership. The private forest is largely coppice, and is in small units, with an average of only about 2 hectares (5 acres) for each owner. Protection forests include two categories: (1) Ordinary conservation zones, which are forest, grazing, or waste lands that should be conserved as a matter of public interest in order to protect the soil on mountains and slopes, to protect springs and streams, to prevent erosion of shores and river banks, and to protect roads, railways, and inhabited places; and (2) compulsory conservation zones in the mountains, where the land is exposed to especial danger of erosion, torrents, and avalanches; and threatens to cause damage to more or less distant localities, arable lands, roads, railways, etc.

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[5] Bulletin Société Centrale Forestière de Belgique 28: 49–51, 342–344 (1921); 39: 81–96, 140–168 (1932). Geneau, G., in Revue des Eaux et des Forêts 70: 349–353 (1932).

[6] Decreto que dá regulamento ao Serviço Florestal do Brasil, 16 Sept. 1925. Translated in International Yearbook of Agricultural Legislation, 1925, p. 379–390. International Inst. Agr., Rome, 1926.

[7] Law on forests, 21 July 1925. Translated in International Yearbook of Agricultural Legislation, 1925, p. 390–454. Internat. Inst. Agr., Rome, 1926.

In the compulsory zone the authorities may require stabilization of the soil through afforestation or masonry work, and the State may contribute 30 percent of the cost of the work. Owners cannot be compelled to spend money on these lands, but if they do not the State can expropriate the land.

Clearing of the forest and conversion to other use is not allowed in either zone, nor may clear cutting be done. The State may prohibit any cutting, grazing, or removal of litter until a management plan is adopted. Such a plan, covering the utilization of the timber, forage, or other products, may be prepared by the owner or his agent and approved by the Minister of Agriculture and Domains. It must insure the continued productivity of the forest but not necessarily sustained yield. Permission of the State forest officer must be obtained before cutting, and unless application is made before July 1 of each year the owner has to pay the officer's expenses in examining the tract.

If the owners of one half of the forests within a given unit agree, the State may require that small areas of mountain protection forests be grouped into larger units so as to facilitate management. The State is obliged to expropriate the lands of those owners who are unwilling to cooperate and to pool its own forests with the others in the unit for purposes of cooperative management.

The State may remove the inhabitants from protection zones; in such an event it pays their moving expenses, grants them better located cultivable land in exchange, and may also grant cash subsidies to help them get started in the new location.

Nonprotection forests are subject to a less degree of control. Grazing is not permitted in plantations less than 10 years old, in coppice stands less than 2½ feet tall, or on naturally reproducing areas under old timber or on burns. The number of stock that may be run on forest lands is subject to restriction, depending upon the character of the forage. The local population may vote to exclude goats. Night grazing is prohibited, and all stock must be accompanied by a herder. Areas of more than 10 hectares (about 25 acres) may not be cut without the permission of a State forest officer. The State is to supply free planting stock to all classes of owners.

Forests other than protection forests may be subjected to further control at the owners' request. Such forests may be cleared where suitable for agriculture, where they will be restocked artificially, where they are less than 10 hectares in area but not part of larger tracts together containing more than 10 hectares, or in cases where an equal area of other land has been satisfactorily restocked. Plantations under 20 years old may be cleared (except where planted as penalty for deforestation).

CANADA

Neither the Dominion nor the Provincial Governments attempt at the present time to regulate the management of private forests. Such control has been proposed, however, notably in Quebec. There, it is reported, "the Minister of Lands and Forests is urging the adoption of legislation similar to that of the Scandinavian countries * * *. It is hoped to bring about an arrangement under which such owners in Quebec would be forced to secure advance authorization for cutting, and to submit to an official checking of the quantities of timber cut." [8]

CZECHOSLOVAKIA [9]

Almost two thirds of the forest land of Czechoslovakia is privately owned. At least two thirds of the private forest is in large holdings of more than 250 hectares (about 620 acres). Forest legislation is based largely on the Austrian law of 1852. Under a law adopted in 1928, all owners of forests over 50 hectares in area must manage them according to approved management plans prepared by qualified foresters. These plans, which must provide for sustained yield so far as it may be practicable, must specify the quantity and location of cutting for 10 to 20 years ahead and must give details as to the areas to be planted during at least 10 years. Until such plans are approved each cutting must be reported, and it is forbidden to cut more than one sixtieth (regulations specify one eightieth) of the area of high forest or one twentieth of the area of a coppice forest in any one year (except locust or oak grown for tanbark). In no case may the cut exceed the annual growth. Cutting of high forest under 60 years old or coppice under 20 years (with minor exceptions) is prohibited unless such cutting is prescribed in the management plan, or unless special permission is obtained. This does not apply to thinnings or necessary improvement cutting. Owners working under approved plans must keep adequate records and must submit certain reports to the regulatory authorities after the end of each year.

For tracts of less than 500 hectares, the plans must be approved by the local district forest authorities; for tracts of 500 to 5,000 hectares, by the provincial authorities; and for tracts of more than 5,000 hectares, by the Minister of Agriculture. An owner may be required to revise his plan before the expiration of 10 years in case of any important change in the economic situation of the forest, or in case the approved plan is evidently resulting in overcutting. Owners of tracts smaller than 50 hectares may be relieved of the necessity of reporting each cutting if they adopt management plans.

DENMARK [10]

In Denmark, nearly 70 percent of the forest is held by private owners. Almost two thirds of this private forest is in units greater than 60 hectares (about 150 acres). Control over private forests is very slight. As long as an owner keeps his forest in good condition he is not interfered with. If he does not do so, the State will carry out such measures as may be necessary to insure restocking, at the owner's expense. Most of the forests are classified as "protected" forests, which may not be cleared. Other forests may be cleared, but must not be devastated so long as they remain forests.

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[8] Frost, Wesley (U.S. Consul General at Montreal), Manuscript report, Oct. 9, 1930.

[9] Deutsche Forstzeitung 43: 786–767 (1928), and 45: 826 (1930).

Loi No. 37 concernant la protection provisoire des forêts, 29 fevrier 1928. In Annuaire International de Legislation Agricole, 1928, p. 346–349. Internatl. Inst. Agr., Rome, 1929.

Décret gouvernmental No. 97 portant exécution de la loi concernant la protection provisoire des forêts 26 juin, 1930. In Annuaire International de Legislation Agricole, 1930. Internatl. Inst. Agr., Rome, 1930.

[10] Koch, A. E., Manuscript on law of Sept. 28, 1805. July 18, 1922. Möller, C. M., "Model forest legislation." In Actes Congrés International de Sylviculture, vol. 2, p. 626–642. Rome, 1926.

A purchaser may not cut timber, except for his personal use, within 10 years after buying a forest unless he gets permission from Government inspectors and has the trees which are to be cut marked by them (at public expense). This is to prevent speculative purchase for the purpose of exploitation. After 10 years he can cut as he pleases, so long as he keeps the forest productive.

Forests may not be divided into tracts of less than 50 hectares (125 acres) nor may large forest estates be broken up into holdings of less than 600 hectares (1,500 acres). This restriction aims to insure the continued employment of trained foresters, which would not be feasible with small tracts. Owners of less than 50 hectares may form cooperatives and employ foresters, half of whose salaries will be paid by the State.

EL SALVADOR[11]

An owner in El Salvador may not clear a forest for the purpose of cultivating the land without permission of the Departmental Governor; land cleared without permission must be reforested within 2 years. Permission to clear land may not be refused, however, except in case of protection forests, the conservation of which is necessary for the protection of soil on mountains or slopes, prevention of erosion by rivers, lakes, and torrents, stabilizing the flow of springs and streams, fixation of dunes, national defense, and public health. In these forests cutting must be done in such a manner as to maintain a reasonably continuous forest cover, and the trees that are cut must be replaced by others of the same or better kinds within 1 year. Outside of the protection forest areas, every owner of more than 45 hectares (about 110 acres) is required to establish a forest at the rate of 1 hectare for each 50 hectares of land. This is not required where the land is too sterile for trees, or where all of it is utilized for more productive purposes.

ESTONIA[12]

Prior to the war, most of the forests of Estonia were in large estates. Upon the establishment of the Republic all private forests of more than 50 hectares (about 125 acres) in area were confiscated by the State. The remaining private forests are under the general supervision of State forest officers.

FINLAND[13]

More than 60 percent of the forest of Finland is owned by individuals and corporations. Sawmill and pulp companies own considerable areas, but are not allowed to acquire forests within agricultural districts. There are a few large individual holdings, but small holdings predominate. Forests must not be devastated or treated in such a manner that natural regeneration is jeopardized. Stands of immature conifer timber may not be cut, but they may be thinned in a rational manner. Where necessary, cut-over areas must be replanted. Clearing of land for crops, pasture, or other use is allowed, provided it is suitable and is actually put to such use. Unless the forest is managed in accordance with a working plan approved by the provincial forestry board, or unless the owner himself is merely making a rational thinning of his woods, the board must be notified before cutting, with information as to time, place, extent, and character of cutting.

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[11] Ley agraria, 1907.

[12] Mathiesen, A., "Die Waldungen Estlands, ihre Bewirtschaftung und der forstliche Unterricht in Estland." In Actes Congrès International de Sylviculture, vol. 2, p. 32–47. Rome, 1926.

[13] Lakari, O. J., "Measures for insuring sustained forestry in Finland." 26 p. Helsinki, 1926.
Cajander, A. K., "The organization of forest administration in Suomi." Silva Fennica 4: 3–19, 1927.
Loi no. 161 concernant les forêts appartenant aux particuliers, 11 mai 1928. In Annuaire International de Legislation Agricole, 1928, p. 333–338. Internatl. Inst. Agri., Rome, 1929

Forestry boards (eight in number) consist of 3 to 5 members each, and an equal number of alternates, all appointed for 3-year terms. The members are chosen by the provincial agricultural societies and societies of rural economy, excepting one, who is selected by the central Government office for the promotion of private forestry. Each board has attached to it a provincial forest inspector (and in some instances an assistant inspector) and provincial rangers averaging 6 to 8 in each Province. Each provincial board is assisted by communal boards, each consisting of at least three members elected by the community.

The provincial boards look out for illegal cutting, and advise and instruct the owners as to methods of reforesting cut-over land, including both that newly cut and that already denuded. Forests that have been mismanaged in violation of the law are subject to rather strict regulation by the boards. As originally constituted, the function of these boards was merely to prevent forest devastation, but the law adopted in 1928 made them responsible also for promoting the development of private forestry through dissemination of information, and assistance in forestry operations and cooperative undertakings. This had previously been left to the agricultural societies, under the supervision of the Board of Agriculture.

Protection forests may be so classified by the Government at the request of the State Board of Forestry, where they are near timber line, on drifting sand, or on steep slopes, where the destruction of the forest cover would threaten to cause damage to other land. Timber in protection forests, except for domestic use, may be utilized only with the sanction of a forest official. As most of the forest that falls in this class is State forest, this law has caused no difficulty.

FRANCE [14]

Two thirds of the French forest area is in private ownership, of which more than half is divided among approximately 1,400,000 owners whose holdings are less than 50 hectares each, with an average of about 2½ hectares (6 acres). Less than one tenth of the area is held by the 700 owners of more than 500 hectares (1,250 acres).

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[14] Bourdeaux, Henry (editor), "Code forestier, suivi des lois sur la pêche et la chasse et code rural." 384 p., Paris, 1930.

Guyot, Charles, "Manuel de droit forestier à l'usage des particuliers proprietaires de bois." 340 p., Paris, 1921.

Guyot, Charles, "Le reboisement et la conservation des forêts privées." 38 p. Paris, 1920.

Revue des Eaux et Forêts 68: 428; 590; 655. 1930.

Loi relative à la reglementation de l'abatage du chataignier, 6 décembre 1928. In Annuaire International de Legislation Agricole, 1928, p. 338–339. Internatl. Inst. Agr., Rome, 1929.

Anterrieu-Vons, "Organisation du service de defense des forêts, etc." In Actes Congrès International de Sylviculture, vol. 5, p. 163–184. Rome, 1926.

The "code forestier" adopted in 1827 and amended in 1859, which still applies to most of the privately owned forests, except very small holdings in flat country, places no restrictions on their management except that no forest may be cleared (i.e., deforested) without four months' advance notice to the proper authorities. The forest service, with approval of the Council of State, may prohibit clearing only in cases where conservation of the forest is deemed necessary for maintaining the soil on slopes or mountains, protecting soil against erosion, maintaining the flow of springs and streams, stabilizing of sand dunes and protection of coasts, defense of the frontiers, or public health. Abusive cutting, where subsequent grazing or browsing of the young growth by rabbits may result in deforestation is considered as deforestation and is forbidden. Areas cleared in spite of such prohibition must be reforested within 3 years; if the owner fails to do this work the forest service will do it at his expense. Notice of clearing is not required in case of artificially established forests under 20 years old, groves near dwellings, or tracts of less than 10 hectares that are not contiguous with larger tracts or on ridges or mountain slopes.

Legislation adopted in 1882 and amended in 1913 provides for the designation by law of mountain areas ("perimeters"), within which the public interest requires reforestation and other work for protection of the soil and regulation of streams or torrents. These areas are to be classified only after examination and hearings by a special commission consisting of administrative officials, local citizens, and representatives of the forest service and the highway department. Within these perimeters the Government carries out the necessary work at public expense, expropriating the land if necessary. Owners may retain their lands providing they agree to perform the work and manage the land subsequently as the forest service may direct. In places where conditions are threatening but not sufficiently serious to require restoration work, the service may forbid any utilization of forest or grazing land for a period not to exceed 10 years. The owner is to be indemnified for any loss of revenue, and if the restriction is extended beyond 10 years he may require the Government to buy the land.

A protection forest law of limited scope was adopted in 1922. Under this law protection forests are those which must be conserved in order to maintain the soil on mountains and slopes, and to protect against avalanches, erosion, and the encroachment of waters and sands. After hearings and recommendation by the special commissions provided in the 1882 law, forests may be classified as protection forests upon recommendation of the forest service, in consultation with the secretaries of agriculture and finance, and within the limits of the credits provided in the budget. These forests are subject to special control by the forest service with respect to the utilization of timber, forage, and other products, and are subject to expropriation by the State at any time. Cutting may be done under approved management plans; in the absence of such plans, permission must be obtained for each operation. The owner is entitled to indemnity for loss in revenue resulting from restrictions on management, and he may demand that the State purchase the forest if the loss amounts to one half of his normal revenue. Any silvicultural or engineering work that is necessary to hold the soil in place can be done by the forest service at State expense. As protection of water supplies and regulation of stream flow are not within the scope of this law, the area of private forests affected is very small.

A special law of 1893 applying only to the Maures and Esterel regions of southeastern France restricts the right to use fire on one's own land, and also provides that any owner can oblige his neighbors to cooperate in maintaining a 20 to 50 meter firebreak along property lines.

Another law, passed in 1924, extends the restrictions of the 1893 law to a larger area (Departments of Var and Alpes Maritimes) and provides for the classification by special commissions of districts particularly exposed to fire hazard. If, within 1 year after such classification, the forest owners within a district have not voluntarily joined in a fire protective association, they may be compelled to do so by decree of the Council of State. By 1926, approximately 270,000 hectares had been classified and 10 cooperative associations had been organized. This same law provides that the prefect, upon recommendation of the forest service and the commission, may forbid grazing for 10 years on burned-over land.

Chestnut forests have been subject to special restrictions since 1928. An owner desiring to cut more than 20 trees (except coppice) in 1 year must notify the prefect in advance, must replace each tree that is cut by a new tree or a sprout within 2 years, and may not pasture goats in plantations or sprout stands less than 3 years old.

Optional control is provided in two laws. A law of July 2, 1913, authorizes owners to contract with the forest service to manage their forests under agreements which must run for at least 10 years. The scope of control, to be agreed upon between the owner and the service, may range from mere police protection to complete silvicultural management. The owner is to pay a fee for this service. It has been reported that the fees demanded by the forest service have been so high that very few owners have taken advantage of the law. Another law passed in 1930 provides for a reduction of the transfer tax on forest lands on condition that they shall be managed according to a working plan approved by the local office of the forest service. As an alternative, if the forest is more than 50 hectares in area, the owner must get the permission of the forest office before cutting, must replant within 5 years if natural reproduction fails, and must also prevent damage from grazing and wild game. These restrictions are to be effective for at least 30 years after the transfer of ownership.

ALGERIA [15]

Only 5 per cent of the Algerian forest is privately owned. The laws relating to use of private forests are patterned closely after the forest code of France. The forest service may forbid clearing (deforestation) where the preservation of the forest is necessary for the protection of soil on mountains or slopes, prevention of erosion by rivers or torrents, stabilization of streams, fixation of drifting sands, national defense, or public health. Areas cleared without permission of the forest service must be reforested within 3 years. If the owner fails to do this, the service will do it at his expense.

Brush-covered or denuded land which needs to be forested for the same reasons may be declared to be of public utility and may be expropriated for purposes of afforestation, at the option of the forest service. If the land is not expropriated, the owners may continue to use it, but may not clear the brush or trees without permission of the service.

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[15] Loi forestiere relative à l'Algérie, promulguée le 21 fevrier 1903, also supplementary decree of the Governor General, dated Aug. 20, 1904.

Abusive exploitation or overgrazing which will result in the destruction of the forest is considered equivalent to deforestation. Grazing on reproducing burns less than 6 years old is prohibited.

Except for the restriction on clearing, owners may manage their forests as they please, but with certain exceptions they must give notice before cutting timber or harvesting other products. Except where it is proposed to clear the land, this is merely to allow the authorities to check up the ownership of the forest and thus prevent trespass.

Burning of brush and slash near forests requires a permit and may be done only if a forest guard is present. An owner of land that is covered with brush or slash may be required by owners of adjoining land to cooperate in clearing a firebreak around his property.

MADAGASCAR [16]

Proprietors enjoy full rights of ownership and use of their forests in Madagascar except that they may not destroy the forest without permission of the Governor General, and must not use fire to clear the land. Permission to clear may be withheld where the conservation of the brush or forest cover is necessary for protection of soil on mountains or slopes, prevention of erosion by streams and torrents, protection of springs and headwaters of streams, stabilization of dunes and seacoasts, or for purposes of public health or national defense.

An owner or operator clearing land without authorization may be compelled to reforest it under the direction of the public authorities at a rate not to exceed 25 hectares a year.

Recent legislation (1930) provides for classification of special "protection forests" and "reforestation reserves". Protection forests which include all forests on lateritic soil with slopes steeper than 35°, may not be exploited without permission of the forest service and not more than 50 percent of the trees may be cut. Reforestation reserves are temporarily closed to all exploitation. They include bare or insufficiently wooded land on steep mountain slopes, littoral dunes, or lands liable to serious gullying, and also isolated forests of less than 500 hectares unless exempted by the forest service.

GERMANY [17]

In Germany, legislation on forestry matters has been left to the individual States. Since the revolution of 1918 a national forestry law has been proposed and widely discussed, but it has not yet been adopted. In order to clear up any doubts as to the authority of the States to regulate private forests, an ordinance was passed in 1924 specifically confirming this authority, subject only to the restriction that an owner must be allowed to manage his forest in his own way, provided he keeps within the limits of "conservative forestry". As each State decides for itself, what constitutes "conservative forestry", practically any degree of control may be adopted. In some of the States the old forest laws are still in force; others have adopted new laws, providing for an extension of public regulation beyond that previously in effect.

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[16] Decree of 1913 establishing régime forestier for the colony.

Décret réorganizant le régime forestier applicable à Madagascar et dépendances 25 janvier 1930. In Annuaire International de Legislation Agricole, 1930, p. 533-542. Internatl. Inst. Agr., Rome, 1930.

[17] Von Arnswaldt, in Allgemeine Forst- und Jagdzeitung 105: 298-306, 1929.

See also Weber, H., Forstpolitik, Ch. XIX, in Handbuch der Forstwissenschaft Ed. 4, Bd. 4. Tübingen, 1927.

The essential provisions of the laws of the principal German states are as follows:

BADEN [18]

One third of the forest in Baden is privately owned. Three fourths of this is in tracts of less than 20 hectares. Only 44 properties are larger than 100 hectares, having an aggregate area of 7,000 hectares, (approximately 17,300 acres). An owner may use his forest as he pleases, so far as this does not interfere with the obligation to maintain it as continuously productive forest. Management on a sustained yield basis is not required. In order to insure that the forest will be continuously productive, deforestation without permission of the State forest service is forbidden, as is also the destruction or jeopardizing of the forest through mismanagement. Where clearing is permitted, the land must be put to agricultural use within a specified period. Permission to clear will not be granted if there are valid objections by neighboring owners, or if the land is not suited for agriculture.

Clear cutting (or its equivalent) requires the consent of the local authority; consent is to be refused unless the applicant agrees to plant the area as directed by the district forest office and unless the success of artificial restocking is reasonably certain.

All plantable forest land which will not become fully stocked naturally must be planted. This includes land already denuded before the law was passed. The district forest office is to see that sufficient planting stock is grown, preferably in the private forests themselves, or, if necessary, by public authorities, and that it is sold at low prices. In case an owner fails to do the required planting at the time and in the way specified, the State forest authorities are to do it at his expense.

If he destroys the forest or utilizes it in a way that threatens to destroy it, his operations may be stopped, he may be fined, and the forest may be put under control of a State forest officer for not less than 10 years. On such a forest the owner must notify the forester by April of the kind and quantity of timber he desires to cut in the succeeding fiscal year. The forester marks the timber to be cut, instructs the owner in methods of felling and removing the timber and by products, and inspects the cutting area to see that his instructions are carried out.

Cutting or hauling of timber at night is forbidden, as is night grazing. The erection of buildings in or near forests, and the burning of charcoal or use of fire for other purposes are subject to restrictions. Forest properties of less than 20 hectares may not be subdivided except by permission of the authorities.

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[18] Muncke, Th. (editor), Das Badische Forstgesetz in seiner jetzigen Gestalt. (Law of 1833 as amended in 1854, and supplementary ordinance of January 30, 1855.) Karlsruhe, 1874.

Eichhorn, Das badische Forstgesetz und seine Erneuerung. Allgemeine Forst- und Jagdzeitung 105: 441–454. 1929.

BAVARIA [19]

About half of the forest in Bavaria is privately owned. Most of the private forest is in small units. Only one fifth of it is managed by foresters. Every owner is entitled to the free use and management of his forests so long as the rights of other parties are not infringed upon, and so long as he complies with the provisions of the forestry law which are designed to insure the maintenance of the forest in a productive condition.

Protection forests include those on ridges, steep slopes, hillsides, and bluffs, those affording protection against avalanches and winds, and those serving to maintain the flow of springs, to prevent the erosion of stream banks, and to fix drifting sands. Such forests may not be destroyed or even clear cut.

Other forests may be cleared only with the permission of the forest authority, provided the land is unquestionably suited for agriculture or other superior use, and provided the owner agrees to put it to such use within a period to be specified. Land devoted to forests must be kept forested and may not be devastated; that is, it may not be handled in such a way as to threaten its continued existence as a forest. Clear cutting is not considered as devastation, provided the land is restocked promptly by natural or artificial means. Areas denuded by cutting or through any other cause following the adoption of the law must be reforested, by planting if necessary. If the owner fails to do this within a specified time, the State foresters will do it at his expense. When forest land or standing timber is sold, the authorities must be notified and a permit obtained before the timber is cut. This may be refused unless reforestation is assured. It may be refused in case of young high-forest stands if less than 75 percent of the trees are 12 centimeters or more in diameter.

Grazing at night or on areas occupied by young growth is forbidden, and livestock must be accompanied by a herder. The use of fire and the erection of buildings in or near a forest are subject to limited control. The owner must carry out such measures as may be required by the authorities in case of insect outbreaks.

A private forest may be subdivided only with the consent of the forest authorities, and in no event may it be subdivided to such an extent that the separate portions are incapable of regular management.

HESSE [20]

Less than one third of the Hessian forest is privately owned. Two classes of private forests are distinguished: Class I forests (about 70 percent of the total), managed by technically trained foresters; and class II forests, which are not so managed. Class I forests do not have to pay the special forest protection tax which is collected from owners of class II forests. All forests must be kept continuously productive, and their yields increased so far as practicable. For clearing of forest land, the permission of a superior forest official is required. Bare land that is suitable for forestry and unused for crops or pasture must be reforested within a period to be fixed by the forest authorities. Private forests, or public and private forests together, may be combined into cooperative units and managed by the State forest service, upon request of the owners. Individual owners also may have their forests managed by the State, under voluntary contract.

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[19] Ganghofer, A. Von, "Das Forstgesetz für das Königreich Bayern." Ed. 2, 381 p. Nordlingen, 1889.
Weber, H., "Forstpolitik," Ch. XIX, in Handbuch der Forstwissenschaft, Ed. 4, Bd. 4. Tübingen, 1927.

[20] Endres, M., "Handbuch der Forstpolitik." Ed. 2, p. 176–178. Berlin, 1922.
Weber, H., "Forstpolitik, " Ch. XIX, p. 365–367, in Handbuch der Forstwissenschaft, Ed. 4, Bd. 4, Tübingen, 1927.

A forest or the standing timber may not be sold without permission of the forest authority, and the State has prior option on any forest that is offered for sale. It is not permitted to break up forest properties so as to make units of less than one half hectare. Protection forests must be handled in accordance with an approved management plan and qualified foresters must be employed.

MECKLENBURG-SCHWERIN [21]

Private owners in this State hold slightly less than half of the forest area. Forest devastation is forbidden, and forest land may not be cleared for other use without permission of the forest authorities. Not to exceed 4 percent of the area of a forest of 25 to 100 hectares may be cut over in any one year. For a forest of more than 100 hectares not more than 2 percent of the area may be cut in any one year, the forest must be managed according to a working plan, and technically qualified foresters must be employed.

Areas on which the volume of timber has been reduced below 40 percent of the original stand, by cutting, fire, or otherwise, must be reforested within three years. If the owner fails to do this, the public authorities will do it at his expense. Existing bare land must be planted within a period to be fixed, and the State will contribute part of the necessary funds for this work. The dividing of forests is forbidden, except as may be allowed by a later law. Forests which serve as recreation spots for people in the cities may not be cut without permission of a special commission which is set up for the purpose.

The supervisory authority is the Agricultural Chamber, working through its forestry committee, which consists of forest owners, representatives of the communal forests, the small owners, and the professional foresters. Appeals from decisions of the Chamber may be taken to the State Department of Agriculture, Domains, and Forests.

PRUSSIA [22]

Half of the forest in Prussia is privately owned. Mandatory control applies only to protection forests, which are those protecting other forests or watercourses from drifting sand, protecting lowlands, roads or buildings against floods or landslides, protecting against winds, or protecting the flow of streams. In these forests, methods of cutting may be prescribed, and planting or other control work required. A special law applying to the headwaters of the Oder, in Silesia, forbids excessive removal of litter, grazing, removal of stumps, or digging of drainage ditches.

Forests may be classified as protection forests upon application of communes, local or district authorities, interested persons who are exposed to danger, or the State police authorities. Forest owners are to be compensated for losses suffered as a result of restrictions, at the expense of the applicants or other persons benefiting from the restriction. Beneficiaries may be required to pay for the construction and maintenance of protection works. Restrictions may not be imposed which will entail a greater loss than the amount of damage that will be prevented.

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[21] Allgemeine Forst- und Jagdzeitung 105: 298-306. 1929.

[22] Manuscript report on law of July 6, 1875.
Allgemeine Forst- und Jagdzeitung 105: 298-306. 1929.
Deutsche Forstzeitung 47: 654-655. 1932.
Weber, H., "Forstpolitik," ch. XIX, p. 415, in Handbuch der Forstwissenschaft, Ed. 4, Bd. 4. Tübingen, 1927.

A 1922 law provides for the preservation of stands of trees near large cities and health resorts, or in industrial districts. Restrictions will be removed in 1937 if interested municipalities or associations do not lease or purchase the forests by that time.

New legislation has been under discussion for several years, but has not yet been adopted. This contemplates extension of public control to all private forests, under the general supervision of a special State forest commission assisted by provincial commissions. Working plans would be required for all forests above a given minimum area, clearing without a permit would be prohibited, and reforestation of cut-over land would be obligatory.

SAXONY [23]

In this State almost half of the forest is privately owned. Three fourths of the private forest is in small units, which for the most part are poorly managed. The average private holding is only 5 hectares in extent. Advance notice of proposed cutting must be given to the State forest service. Certain restrictions are imposed on the cutting of immature timber. Decisions of forest inspectors are subject to review by a central board, which includes representatives of the State forest service and of communal and private forest owners. Bare forest lands must be reforested at an early date, under general supervision of the State foresters. Intervention in the management of well-kept private forests is not contemplated.

THURINGIA [24]

About half of the forest in Thuringia is privately owned. The forest law of 1930 requires that all forests, regardless of ownership, must be managed conservatively. For clearing forest land, permission of the forest authorities must be obtained, and advance notice must be given of any clear cutting in excess of one half hectare (about 1¼ acres), unless it is done under an approved working plan. The owner of a forest over a minimum size to be fixed by the Finance Department must employ a qualified forester and a protective force, or be a member of a silvicultural association, or put his forest under the control of the central agricultural chamber (Hauptlandwirtschaftskammer). At the owner's request, the State will take over the management and protection of any forest, for a stipulated fee to be paid by the owner. The cutting and sale of timber is left to the owner. Under certain conditions forests may be classified as protection forests, and then their management is subject to a greater degree of public control.

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[23] Steger, C. T. (United States vice consul), Manuscript report on law of October 25, 1923. (Dec. 14, 1923.)
[24] Deutsche Forstzeitung 45: 1119–1120. 1930.

WURTTEMBERG [25]

Only one third of the forest is in private ownership in Wurttemberg. Clearing of forest land (deforestation) requires the permission of the Department of Finance, following a recommendation of the forest service. Permission will not be granted where the clearing will break up a contiguous forest unit or will endanger adjoining forests, or for forests on heights or those which afford protection against wind. Permission to cut clear or to thin heavily may also be withheld where the forest officer determines that the forest should be kept intact in order to prevent damage through landslides, soil washing, or windthrow of adjacent conifer forests.

Forest officers may require the modification of cutting and other practices, including excessive grazing and removal of litter, which endanger the continued existence of the forest. The owner must give notice of outbreaks of insect and other pests and must carry out control measures as directed.

Bare land suitable for timber production (whether denuded by the owner or not) must be restocked within a specified period; if it is not, the work will be done by public agencies at the owner's expense.

The owners of small tracts may combine them for purposes of management, and may arrange with the State forest service to provide technical supervision and protection. The owners are to pay an agreed sum for this service.

GREAT BRITAIN

Neither in Great Britain itself nor, with one or two minor exceptions, in other parts of the British Empire has the Government undertaken to exercise any control over the management of privately owned forests. The necessity for some degree of control is coming to be recognized, however, particularly since the World War. The report of the Third British Empire Forestry Conference (1928) contains the following statement:

> It is suggested that legislation might provide for the protection of water sources and the prevention of erosion and shifting cultivation, matters which the discussions show to be of prime importance in many countries. Similarly, it was thought that governments who have not hitherto done so, might in certain circumstances take power to assume, on conditions, the management of private forests in the public interest.[26]

The annual report of the Forestry Commission of Great Britain for 1929 contains the following:

> The measures which the commissioners have taken to improve private forestry consist of provision of grants for planting, technical advice as to the conduct of operations and educational facilities, the conduct of research and the dissemination of information. These activities * * * have not been successful in arresting the deterioration of the home woodlands in private ownership, much less in restoring the pre-war position.
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> There are three main lines of action to which recourse is possible: (1) State assistance * * *; (2) restrictions on the user of woodlands, such as State permission to fell or compulsory replanting * * *; (3) acquisition and replanting by the State of felled and derelict woodland. This procedure has already been applied by the commissioners, but purely on a voluntary basis.
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> In reviewing the whole situation with regard to private forestry the commissioners have come to the conclusion that while they do not suggest any immediate

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[25] Forstpolizeigesetz vom 19 February 1902 (and supplementary instructions of July 30, 1902).

[26] Third British Empire Forestry Conference, 1928, Summary Report, Resolutions, and Reports of Committees, p. 7.

changes, it may become necessary in due course to ask Parliament for additional powers.[27]

GREECE[28]

Private owners control slightly more than one fifth of the forest area of Greece. The forest code adopted in 1929 gives the state a general right to supervise the administration and exploitation of private forests. These must be handled in accordance with management plans prepared by trained foresters and approved by the Minister of Agriculture upon recommendation of the Council of Forests, an advisory body composed of Government officials, technical foresters, and representatives of forest owners and industries. These plans must be revised at least once every 10 years. Owners of small tracts may form cooperatives for the protection, management, or exploitation of their forests, and such cooperation may be required if one third to one half of the owners in a given unit so request.

Protection forests, to be classified by the forest service upon application by local officials or interested parties, include forest, pasture, or cultivable land on which the public interest requires that a forest cover be maintained to protect the soil on slopes, to protect land lying below from snow and earth slides and soil washing, to protect land from floods, coastal erosion, or drifting sand, or to protect the shores of lakes and streams, roads, railroads, habitations, monuments, and historical spots. Any cutting in protection forests which denudes the land or jeopardizes its continuous productivity is prohibited, and the Minister of Agriculture, with approval of the council, may forbid any cutting, cultivation, or grazing. In general, selective cutting is allowed, after due notice, and in coppice forests small areas may be clear cut. Cutting of trees around sacred, historical, or artistic sites is prohibited, except as partial cutting may be authorized by the Minister. Owners cannot be compelled to undertake improvement works at their own expense, but if such work is deemed necessary and the owners are unwilling to do it, the state may expropriate the land.

With the approval of the local forestry commission and the Council of Forests, the Department of Agriculture may classify land as in need of reforestation or afforestation. This includes land with scanty or no natural tree growth which should be forested for the reasons enumerated above, as well as land bordering highways and railroads. Owners of large estates (over 3,000 stremma, or 300 hectares) may be required to afforest up to 15 percent of their land, depending on its character. The forest service furnishes seed and plants at low prices for planting classified lands, and may do the planting in case an owner refuses. In that case the owner is required to pay the same royalty when timber is cut as though it were on a state forest. Clearing, cultivation, or grazing of these lands is forbidden, except that a limited amount of grazing may be permitted by the Minister of Agriculture.

Owners may be required to construct and maintain firebreaks around forests that are especially subject to fire, and owners of pine forests may be required to adopt other preventive measures, such as thinning or pruning the stands. Fires may not be built in or near forests between May 1 and September 30 unless proper precautions are taken. Cost of extinguishing fires on private land is to be collected from the owners. The timber in burned forests may not be exploited for 5 years after the fire, nor may the land be cultivated for 10 years, if the owner was responsible for the fire or failed to take suitable measures to prevent and suppress it. After a fire, sheep, cattle, or horses may not be pastured on the burned forest land, whether reforested or not, for 5 years, nor goats for 15 years.

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[27] Tenth annual report of the forestry commissioners for the year ending Sept. 30, 1929, p. 30–31.

[28] Loi No. 4173 sur la sanction et modification du décret-loi du mai 1929 "sur le code forestier", 17 juin 1929. In Annuaire International de Legislation Agricole 1929. Internatl. Inst. Agr., Rome, 1930.

GUATEMALA[29]

Forests at the headwaters of publicly used springs and streams in Guatemala may be declared to be of public utility, and are then subject to control. Other forests may be put under control of the forest department if the owners request it.

Strips at least 275 feet wide must be left uncut along crests and ridges; forests on high lands or slopes may not be cleared where this will result in landslides or washing of the soil that will jeopardize the life or property of others; nor may forests be cut above or within 100 meters of springs belonging to other owners. For each tree cut in the pine and coffee regions, three trees of the same species, or five of some other valuable species, must be planted in the same year at the beginning of the rainy season; if the planting does not succeed, it must be repeated under the supervision of forest agents. The local magistrate and neighboring owners must be notified before land is burned over.

HUNGARY[30]

Two thirds of the forest in Hungary is privately owned. The forest law of 1879 and later amendments prohibited deforestation of "absolute forest soil", regardless of its ownership. Mountain forests which should be preserved for their protective functions were to be classified by a special commission within five years after adoption of the law. Clear cutting is not allowed in protection forests, and they must be managed according to management plans approved by the forest department. Grazing on ravine lands liable to erosion is subject to certain restrictions.

Industrial corporations owning forests must follow approved management plans and employ trained foresters. Under a law adopted in 1918 private forests which are not handled under such plans are subject to public control, and must be kept productive.

New forest legislation was under discussion in 1930.

IRISH FREE STATE[31]

Private owners hold four fifths of the forest area of the Irish Free State. Restrictive legislation is based on the public interest in preserving the amenity values of trees and woodland, rather than on protection of soil or water resources.

An owner must notify the authorities three weeks before cutting trees that are more than 10 years old. The Minister of Agriculture may prohibit cutting unless replanting of the same or an equivalent area within 12 months is assured. The State may subsidize planting up to £4 an acre. Cutting may be prohibited altogether where it is desirable to reserve the trees for scenic reasons, in which case the owner is to be compensated. The Minister has the power to buy out any grazing rights or rights to dig turf which may interfere with forest conservation. General permits, which may be issued for definite periods, may allow cutting that is in accordance with good forest practice.

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[29] Ley forestal approved by Legislative Assembly Mar. 24, 1925. In El Guatemalteco, Apr. 16, 1925.

[30] Fernow, B. E. A Brief History of Forestry, pp. 181–182. Cambridge, Mass., 1911.
Commission du Régime des Eaux du Danube, 8th session, Avril, 1925, Protocoles, p. 45.

[31] Quarterly Journal of Forestry 24: 207–208.
Saorstát Eireann, Forestry Act (Acht Foraoiseachta). 1928.

ITALY[32]

State intervention in the handling of private forests in Italy is justified chiefly on the grounds of public welfare involved in the protection of soil and control of water. Three fifths of the Italian forests are privately owned, mostly in small tracts. In general, owners are not required to give notice or to obtain permission for ordinary cutting in their forests, nor are they obliged to follow management plans. They may not, however, clear forest land for another form of use without the permission of the provincial forest organization. If a forest is being utilized in a manner which threatens its existence, the forest authorities (forest militia) may prescribe the method of use or suspend exploitation altogether.

The 1923 law provides for a forest commission in each province consisting of the forest inspector or his deputy, a civil engineer, an agricultural expert, and an expert on mountain problems chosen by the Minister of National Economy, two members nominated by the provincial council, and a special representative from each commune to sit with the commission when dealing with matters affecting his own commune.

Lands where the destruction of the forest, brush, or other cover will lead to erosion of the soil or will disturb the flow of streams, to the injury of the public, are to be classified by the commissions, upon application of the forest service or other interested party, as protected or ban forests. Such land may be cleared for cultivation or other use only with the consent of the forest militia, and in the manner prescribed by it. When the clearing of mountain land is permitted, the slope must be reduced to not more than 20 percent by means of terracing, and canals must be built to carry off the surface drainage without washing. The method of using the timber and forage is also to be prescribed, including season and method of cutting, length of coppice rotation, use and control of fire, control of insects, and time and intensity of grazing. An owner must notify the forest authorities in case of insect or disease outbreak threatening to destroy his own forest or to spread to other forests. Goats may not be grazed on protected areas, nor any stock on reproduction areas until the young trees are old enough to escape injury, nor in poorly stocked forests until reproduction is assured. Where it is necessary for the revegetation or stabilization of the soil of protected areas, all grazing may be suspended for a maximum period of 10 years. Any diminution of revenue is to be allowed for in assessing the land for taxation.

Forests which protect land or buildings from avalanches, falling rocks, drifting sand, and winds; or those which should be preserved for hygienic reasons or for the national defense are also to be classified as protected forests when requested by the provinces, communes, interested private parties, or the appropriate Government departments. Such forests may not be cleared. Those benefiting from restrictions on the use of such forests must indemnify the owners for any loss of revenue that they may sustain by reason of the restriction.

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[32] Riordinamento e riforma della legislazione in materia di boschi e di terreni montani, Regio decreto, 30 dicembre 1923, no. 3267. Liberia dello Stato, Rome, 1924. Also amendment in Regio decreto-legge, 3 gennaio 1926, no. 23.

Merendi, Ariberto, manuscript report in files of Forest Service. 1932.

Paillié, M., "Rapport sur l'intervention de l'Etat dans la gestion des forêts particulières d'après quelques législations récentes." In Actes Congrès Internationale de Sylviculture, vol. 3, pp. 32–53. Rome, 1926.

The state, through the Ministers of National Economy and Public Works, can select watersheds needing control work (reforestation or engineering) and carry out such work; the owner is to be indemnified for any loss of income. After the work is completed the land is to be returned to the owner, but will remain subject to restrictions on its use. Land that has been reforested must be kept in forest and handled in accordance with an approved management plan, and may not be grazed until the young growth is beyond the risk of danger. In case the owner is unwilling to accept these restrictions the state is authorized to buy the land. The owners themselves may carry out the necessary control work, on the basis of an approved plan, and may be reimbursed by the State for their expenditures. The forest service, provinces, or communes may also temporarily or permanently expropriate lands within the protected zones, in order to afforest them, improve existing forests, or stabilize dunes.

Associations may be formed for the reforestation of protected areas. If such an association represents four-fifths of the area to be reforested, it may expropriate the lands of remaining owners who are unwilling to join. These owners must be bought out if they demand it.

Any owner afforesting brush, grass, or denuded land under the supervision of the forest authorities is entitled to certain tax exemptions, and if it is in a protected area the State will provide free technical supervision, free seed or plants, and will pay up to two thirds of the cost of the work.

JAPAN[33]

The maintenance of a forest cover in the mountains is especially important in Japan, because of the steep topography, with soils and rock particularly susceptible to erosion, and the heavy rainfall. Regular flow of the rivers is desirable because of their extensive use for power and irrigation. Forty percent of the forest is privately owned.

The local governor may prescribe the method of working (including gathering of litter, etc.) in private forests which are threatened with destruction, and may stop operations and order the reforestation of cut-over areas where such instructions are not complied with. He may also order the reforestation of land denuded before the law was passed. If the owner fails to plant when ordered to do so, it is to be done at his expense by public agencies.

It is forbidden to burn over forest or wild land without a permit and without prior notice to owners or managers of neighboring forests. Owners must combat insect outbreaks.

Protection forests are to be classified by the competent Minister in accordance with the recommendations of the local forest commission, upon application of a municipality, a local authority, or other directly interested party. These are forests which are necessary for protection against soil denudation, drifting sand, flood or wind damage, avalanches or rock slides, for the regulation of water supplies, the protection of fisheries or the public health, the guidance of navigators, or the protection of scenic beauties at shrines, temples, or historical sites.

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[33] Forest Act of Japan. Act 43, Apr. 23, 1907, revised by Act 75, June 1911. Department of Forestry, Tokyo, 1926.

No one may cut timber, gather by-products, or graze stock in protection forests without the permission of the local governor, who may prescribe the methods of utilizing the forest and may stop cutting altogether for a period of one year. An owner is entitled to compensation from the Government for any direct loss resulting from restrictions, including the cost of any reforestation that he may be required to undertake. The Government may reimburse itself through assessments against those who benefit from the restrictions.

Cooperative societies may be formed for the purpose of undertaking to prevent forest devastation, to restore devastated forests, or to maintain the safety of the land. Two thirds of the owners, representing at least two thirds of the area involved, must give their consent. These cooperatives are under the control of the competent Minister and the local governor.

LATVIA [34]

Only about 15 per cent of the forest in Latvia is privately owned. All forests of more than 50 hectares (about 125 acres) are subject to the forestry law, which provides that cutting must follow the established rules of sound forest management. In the case of forests which serve to prevent drifting of sand or which should be preserved for esthetic reasons, cutting is subject to special restrictions and may be prohibited altogether.

LUXEMBURG [35]

Private forests in Luxemburg are free from restrictions except that clearing on slopes of more than 35 degrees requires a permit. This may not be refused if the area is suitable for building purposes, mining, or grape growing, or if the timber stand is less than 20 years old, or is adjacent to a dwelling.

MEXICO [36]

No cutting is allowed in private forests in Mexico without the consent of the Department of Agriculture, which may establish regulations governing such cutting. Timber must be cut with a saw, not with an axe. All owners or managers must take the necessary precautions to avoid starting fires, must extinguish those on their own land, and must assist in extinguishing those on neighboring property. No exploitation will be authorized until a plan for reforestation has been submitted. Individuals or organizations exploiting communal, municipal, or private forests must carry out artificial reforestation: (1) Wherever natural reforestation will not take place, in the judgment of the local forest inspector; (2) where repeated coppicing has resulted in marked degeneration of the forest;

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[34] Teikmanis, André, The Timber Problem. In League of Nations Economic Committee report. Geneva, 1932.

[35] Endres, Forstpolitik. Ed. 2, p. 220. 1922.

[36] Ley forestal, Apr. 5, 1926. Diario Oficial no. 45, Apr. 24, 1926. Translated in International Yearbook of Agricultural Legislation, 1926, p. 202–206. Internatl. Inst. of Agr., Rome, 1927.

See also supplementary executive decree of May 6, 1932, on reforestation, in Mexico Forestal 10:78–79, 1932.

(3) when a stand is clear cut and the land is not to be cultivated; or (4) when the total cut exceeds 2,500 cubic meters of logs in the temperate belt or 1,000 cubic meters in the tropical belt. The trees that are cut must be replaced by trees of the same or better kinds.

The department may at any time order owners to restore vegetation destroyed by artificial or natural causes. If the owners are unable to do this, the department is to help them. If the executive (through the department) believes that certain lands should be afforested because of their location or for topographic or hydrological reasons, or for any other cause, it may order such work to be done under penalty of expropriation of the land. The Federal Government or the States may expropriate private woodland or bare land for forest reserves, for reasons of public utility.

All wood-using industries must utilize wood completely, without waste. Timber used for posts, mine props, and other uses where frequent renewal is necessary must be treated with preservatives.

NETHERLANDS [37]

Although more than 80 percent of the forest land of the Netherlands is privately owned, there are very few restrictions on its management. In order to prevent serious forest insect infestations, unpeeled conifer logs may not be left in the woods between May 15 and August 1. An owner must take reasonable precautions to prevent the spread of fires caused by railroads or tramroads. Those who do not take such precautions are not entitled to collect damages from the railroad or tramroad company causing a fire.

A recent law (1928) provides for reduction in taxation of forest property having especial scenic or recreational value, provided the public is allowed access to it. Land that comes under this law is to be subject to sufficient public control to safeguard its scenic value, and an owner must notify the forest service before cutting timber. The state, or a municipality, or a recognized foundation incorporated for the preservation of natural beauty may expropriate forests in order to protect the beauties of nature, and cutting in such forests may be forbidden pending expropriation.

NORWAY [38]

Nearly 80 percent of the productive forest area of Norway is privately owned, and 70 percent is owned by farmers.

The township (herred) councils or individual parishes may, by resolution ratified by the King, adopt regulations for preventing the destruction of private forests within their respective territories, except those on homesteads (farm wood lots). These regulations may cover the methods of cutting and managing the forests, except that clearing shall be allowed where the land is to be used for gardens, crops, meadows, buildings, roads, etc. Restrictions on grazing seasons, incorporated in an earlier law, are no longer provided. The regulations may distinguish between commercial cutting and that for domestic use; owners or users may be required to utilize dead trees and other waste material before cutting green trees; burning of brush land may be forbidden except with the approval of the forest inspectors. Owners may be required to deposit a cash guarantee that the area will be restocked in case of cutting for sale or for industrial use; this is deposited in a savings bank and returned to the owner with interest after the reproduction has become well established.

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[37] Boschwet 1922—Wet van den 19den Mei, 1922, houdende bepalingen betreffende den boschbouw. Staatsblad van het koninkrijk der Nederlanden.

Van Dissel, E. (Director of State Forest Administration of the Netherlands), manuscript report in files U.S. Forest Service. January 1932.

[38] Lov av 7 juni 1916 om tillaeg til lov om vernskogens bevarelse og mot skogens ødelaeggelse m.v. 8 august 1908. Also Law of August 8, 1908, on preservation of protection forests and prevention of forest destruction. (Translations by S. T. Dana.)

Lov nr. 4 om forandring i lov om vernskogens bevarelse og mot skogens ødeleggelse m.v. av August 1908—6 juin 1930. *In* Annuaire International de Legislation Agricole. 1930. Internatl. Inst. Agr., Rome, 1930.

Nieuwejaar, Otto, "Norwegian laws concerning protection forests and the prevention of forest destruction." Journal of Forestry 29: 87–91. 1931

The governing councils of the townships or the parishes, as the case may be, may appoint township or parish forest boards consisting of five residents, at least three of whom shall be forest owners. These boards (or the councils if no boards are appointed) issue instructions and supervise the enforcement of the law and regulations. They appoint forest inspectors or rangers, who are paid half by the township or parish, and half by the state if the regulations and provision for their enforcement are approved by the state forest service.

A supplementary law of 1916 applies to all parishes which had not already adopted regulations for private forests. This forbids the cutting for commercial purposes or industrial use of conifers under 20 centimeters (approximately 8 inches) in diameter, except that suppressed or unthrifty trees or others which should be removed for the good of the forest may be cut after being marked by a state or county forester. The forest board must be notified at least 14 days before cutting any trees for sale or industrial use. Leaving of seed trees may also be required.

Under the 1908 law, as amended in 1930, protection forests may be classified by the forest service, acting in collaboration with a commission of three members, two of whom must be forest owners. Such forests may be those protecting against landslides, floods, drifting sand, or those necessary for the protection of an adjoining forest or cultivated land, or those which, because of their situation (high altitude, latitude, proximity to the coast, etc.), would become devastated if heavily cut or otherwise misused. Boundaries of such forests must be marked. Provisions for the protection of these forests are to be drawn up in each case by the forester of the district or by a forester appointed by the forest service, and must be agreed to by the county or township commission (see above) and ratified by the King. No timber may be cut in protection forests except in a manner prescribed by the forest service; upon request by the owner the trees to be cut will be marked by the forester in charge.

PERU [39]

Most of the forest land of Peru is still in public ownership. The only public control over private forests is the requirement that permission must be obtained before cutting timber near the seacoasts or in the mountains within 20 kilometers of railroads.

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[39] Executive decree of Dec. 30, 1919.

POLAND [40]

Two thirds of the forest area of Poland is privately owned, and two thirds of the private forest is in fairly large holdings.

Forest land may not be cleared for other use without special permission. Nonprotection forests of less than 5 to 10 hectares, depending on the province, are not subject to this restriction unless they are contiguous to larger tracts. Forests that are clear cut or denuded in any other manner must be reforested artificially within three years unless natural regeneration is assured.

All forests must be managed under approved working plans on a sustained yield basis, and no cutting (except to salvage dead or down material) may be done that is not provided in the plan. Grazing is prohibited in stands less than 15 years old or less than 3 feet tall.

The owner must notify the authorities of insect outbreaks and must use reasonable effort to combat them.

Protection forests (classified by the forest service upon its own initiative or upon the petition of interested parties) are those deemed essential for preventing erosion, loss of soil fertility, land or rock slides, washing of stream banks, drifting sand, or formation of torrents, and those important for the national defense or for scientific purposes. Such forests may not be destroyed in order to make other use of the land. The methods of cutting and grazing are subject to the general control of the forest service and the direct control of the district and provincial administrative councils.

PORTUGAL [41]

Private forests in Portugal, if located within zones which have been declared to be of public utility, are subject to public control on the ground that a forest cover is necessary in order to regularize the flow of streams, prevent flood damage to the lowlands, protect ridges and waste lands, ameliorate the climate, or fix and conserve the soil in mountain regions and coastal dunes. This classification is made by the Minister of Agriculture, with the advice of the forestry section of the Superior Council of Agriculture.

The State polices these forests, helps in drawing up working plans, provides free seed and planting stock and technical direction of planting operations, and exempts plantations of more than 1 hectare from property taxes for 20 years.

The owners of classified forests must manage them according to working plans approved by the forest service, must employ a forest guard for each 500 hectares (about 1,250 acres) of forest in flat country or 350 hectares (875 acres) in the mountains (or share the cost with the State where small properties are situated close to State forests), and must report all sales, leases, or exchanges of land or timber within 30 days. The customary methods of exploitation are allowed, but the land may not be clear cut or the stumps removed unless the whole area is to be immediately reforested by sowing or planting.

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[40] Revue des Eaux et Forêts 68: 393. 1930.
Deutsche Forstzeitung 45: 116–117. 1930.
Annuaire International de Législation agricole 1927, p. 122. Internatl. Inst. Agr., Rome, 1928.
Swinarski, Teodor, "Der Schutz der Privatforsten in Polen." Vierteljahrshefte der Polnischen Landwirtschaft 1: 58–77. 1929.

[41] Bulletin de la Société Centrale Forestière de Belgique, 30:16–21. 1923.

Any infraction of the working plan or failure to carry out reforestation as required may be punished by a fine or by expropriation of the land. An owner also may request that land subject to mandatory control be expropriated. The income from the sale of timber and land from the State domain is to be used exclusively for the purchase and afforestation of land to be managed as public forest.

Under the law of 1901 private forests outside of the zone of public utility may be submitted to control upon the request of the owners, either individually or through associations. Forests subjected to such optional control are entitled to the same benefits and are subject to the same restrictions as those subject to mandatory control, except in the case of what is called "simple police control", in which the owner merely desires public assistance in reforesting and protecting his forest. In this case planting stock and technical help in planting are furnished at cost instead of gratis, and the owner is not obliged to follow any set plan of management.

Since 1927 all private owners have been required to obtain permission before cutting, unless their forests are handled under approved working plans.

RUMANIA[42]

About 40 percent of the forest area of Rumania was privately owned in 1922, but agrarian legislation allotting public land to the peasants has resulted in a considerable increase in private forest since then. A large part of the standing timber is controlled by large owners or industrialists, either through direct ownership or through lease.

Mandatory control is applied to protection forests; that is, those on the crests and slopes of mountains and hills or on the headwaters of torrents, as well as any others serving to prevent landslides, erosion, or washing of stream banks, to protect roads or railroads on or near steep slopes, stabilize drifting sands, or to regularize stream flow; and those needed for the national defense (upon recommendation of the Minister of War).

Such forests must be managed according to working plans, or equivalent plans of operation, prepared by qualified technicians and approved by the Technical Council. Deforestation is not allowed. In case of cutting within 12 years, a guarantee fund must be deposited with the Ministry of Domains to insure that the area will be reforested. After 12 years this deposit may be dispensed with, providing the owner has managed his forest for at least 10 years in such a manner that the cut-over areas are well stocked and in good condition. If the owner or operator fails to reforest satisfactorily within the period prescribed in the plan, the State will do it at his expense.

Grazing may be allowed only to an extent that will not endanger the regeneration of the forest. It is not allowed in even-aged stands less than 30 years old which have followed clear cutting, in coppice less than 15 years old, in selection forest with a cutting cycle of less than 15 years, or in any forest where gullying has started or is threatened.

In nonprotection forests stock may not be grazed in stands less than 10 years old (except those of willow, cottonwood, and the like, which may be grazed after 3 years). Deforestation (including destruction by overgrazing, by burning, or by overcutting contrary to an approved working plan) is forbidden with certain exceptions, and then requires the approval of the Minister of Agriculture and Domains, after a field examination and recommendation by the Technical Council.

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[42] Sburlan, A., "Die Wälder Rumäniens deren Holzindustrie und Holzhandel." Centralbl. f.d. Gesamte Forstwesen 55:49-70. 1929.
Rumanian Code forestier. Apr. 1, 1910

Forest other than protection forest may be subjected to the régime forestier upon application by the owner. The State is to encourage the reforestation of all forests by having State forest officers make working plans when requested to do so by the owners, by furnishing seed and plants free or at cost, and by premiums and tax reductions in return for good forest management.

RUSSIA [43]

Although, strictly speaking, there are now no private forests in the Soviet Union, considerable areas of forest have been turned over to the villages and agricultural communes, workers' associations, and even to individuals, for use and management. These are practically equivalent to private forests. The holders must protect them from fire, theft, and overgrazing, and must follow working plans prepared by the Provincial Forest Department at the cost of the user. Openings that will not reforest naturally must be replanted. Clearing for other use may be permitted under suitable restrictions. If users fail to comply with these requirements the forests may be taken from them.

Exploitation of most of the state forests is under control of the Supreme Economic Council, and is not subject to regulation by the forestry authorities. Cutting on a large scale has been done without regard to the perpetuation of the forests, and great areas have been devastated. In view of the evil effects of denudation in certain regions, the Government in 1931 provided for a segregation of forests of silvicultural importance, to be protected and managed by the Commissariat of Agriculture. These forests include those of the poorly forested districts of the south and east and those on the headwaters of certain rivers such as the Volga, the Don, and the Dnieper. Cutting in these forests must be gradually reduced so that by 1935 it does not exceed the annual growth. All forests in a 1-kilometer strip on each side of the lower and middle reaches of the Volga, Don, Dnieper, and Ural Rivers are declared protection forests, in which only dead and defective timber may be cut.

The former forest law (that of 1888) provided for various degrees of public control, depending on the situation of the forest. Local forest boards were set up in each province and district, consisting of representatives of the local administration, forest owners, foresters, and a local justice, with the governor as chairman.

The board's permission was required before forest land could be cleared, but it was usually granted (except in case of "protected" forests) where the land was suitable for agriculture. Except in clearing land it was not permitted to cut in such a manner as to prevent natural regeneration, or to pasture cattle on land stocked with young growth. Owners of nonprotection forest could submit a working plan to the board, and if it was approved they were allowed to operate under it without further restriction. The Government provided free technical advice, plants, and seed free, or at cost, and long-term loans on forests managed under working plans.

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[43] Der Forstkodex der Russischen Socialistischen Föderativen Sowjet-Republik. (Translated into German by E. Buchholz.) Forstwissenschaftliches Centralblatt 51:132–146. 1929.
Fernow, B. E., A Brief History of Forestry, pp. 264–268. Cambridge, Mass., 1911.
Buchholz, Erwin, Die Wald- und Holzwirtschaft Sowjet-Russlands. 131 pp. Berlin, 1932.

Forests on the headwaters and upper reaches of streams (except in the Caucasus and certain northern Provinces) were classed as protected forests. These were subject to the same restrictions as the nonprotection forests, and in addition the forest board could prohibit clearing unless the area was so small that no harm would result.

A third class of forest included the protective forests, which were those protecting drifting sands, banks of rivers and other waters, and mountain slopes liable to erosion, landslides, or avalanches. These forests were classified by the forestry boards, and were required to be managed under working plans prepared (without cost to the owner) by the Crown forest department and approved by the board. Conversion to farm use was prohibited, and the board could prescribe in detail the method of management and utilization. All protective forests were exempt from taxation. Expropriation was provided for in case an owner refused to incur the expense of the measures imposed by the board, but he was allowed to recover his forest at any time within 10 years by paying the costs, with interest.

SPAIN [44]

In 1930, three fourths of the forest land (about one half of the productive forest) of Spain was in private ownership. Under legislation then in force, clearing of forests (deforestation) is forbidden except to put the land to agricultural use and upon written agreement that it will be thus utilized within a reasonable time. Permission to clear must be obtained from the civil governor, after consultation with the forest or agricultural officer of the district, or both of them. Permission of the Governor must also be obtained before converting coppice-with-standards to simple coppice.

Clear cutting, except where the land is to be cleared, is also forbidden. An owner may cut not to exceed one fifth of the total number of trees during any 10-year period in forests of the principal commercial species, or during a 5-year period for fast-growing species such as poplar, aspen, willow, birch, alder, and eucalyptus. This restriction does not apply to coppice stands, but in those the stumps must not be uprooted. It also does not apply to tracts of less than 5 hectares, or to forests cut in accordance with working plans where the cut does not exceed the annual growth. Certain exceptions are also allowed where the forests are comparatively inaccessible or where ties are being cut for the national railways, so long as sufficient young trees are left to insure the continued existence of the forest. Stands that are planted expressly for production of posts and mine props may be cut clear if the land is replanted within a year. To take advantage of these exceptions, special permission must be obtained from the civil governor upon recommendation of the municipal authorities. Within the above limitations, the owner is not required to report any cutting.

Two thirds of the fines collected for violations of the law go into a special fund which is used to reward those who restock bare lands.

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[44] Real decreto de 3 de diciembre de 1924 regulando las cortas y descuajes en los montes de propiedad particular, y instrucciones para su cumplimiento.

SWEDEN[45]

In Sweden, more than three fourths of the forest is privately owned, and more than half of this belongs to farmers. Control over the management of private forests is vested in the provincial forest conservation boards, of which there are some 24. There is no central board, and these boards are entirely independent of the State forest administration, although they cooperate closely with it. An owner may appeal from the board's decisions to (1) the provincial government, and (2) the King. The boards under this law consist each of three persons acquainted with local conditions, one representing the National Government, one the local government, and one the local timber owners' association. If there is more than one association, each has a representative, and the local government's representatives are increased accordingly. Each board employs a technical forester as secretary, as well as assistants, rangers, and office staff. It is the duty of the boards to inspect private forests, enforce regulations, and promote forest management through extension and demonstration. Each parish may have a similar local board of three members, one appointed by the county board and two by the parish vestry board.

A forest conservation tax or a severance tax is collected, amounting to 1.3 percent of the value of the cut wood. Of this, 90 percent goes for the support of the conservation board in the district where collected, and 10 percent goes to the national treasury for distribution, if necessary, among other districts. The boards also receive subsidies from the central and provincial governments, and some income from the sale of seed and planting stock, etc.

In most of the provinces young forests may not be felled except to fill domestic needs where no other timber is available, or unless such cutting is in accord with good forestry principles (thinning) and done with the permission of the forest conservation board, under such restrictions as the board may impose. Older forests may not be cut in such a manner as to imperil the regrowth of the forest, nor may the ground be treated after cutting in a way that will prevent forest reproduction. Unless authorized by the board, no cutting may be done, except for domestic use of the owner, which will not leave enough timber to meet future domestic needs. An owner may ask the board for a statement as to the legality of any proposed cutting, and any cutting done in accord with such a statement will be legal. The board may prohibit cutting that is being done or that there is reason to believe will be done contrary to regulations or stipulations. The provincial forester may be authorized to enforce this provision, subject to confirmation by the board itself within 10 days.

Unless reproduction takes place within a reasonable time after cutting, the owner may be required to restock the land by artificial means. He may also be required to reforest areas destroyed by fire, storm, insects, grazing, etc., but unless such destruction was his own fault he may not be required to spend more than the salvage value of the damaged timber, plus any compensation (such as insurance) that he may have received for the loss. The board is to agree with the owner as to the measures necessary to insure regrowth. In case of failure to agree, the county government may be requested to appoint an investigating committee which will report its recommendations, and if necessary a court may decide the matter. If the required measures are not carried out within the specified period, the board, through its forester and two other persons, in company with the owner, is to make an investigation and, if necessary, to carry out the measures at the owner's expense. The board may also require a deposit to guarantee reforestation where artificial reforestation is likely to be necessary because of the method of cutting.

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[45] Law of July 24, 1903 (Protection forests). Law of July 24, 1903 (Västerbotten and Norrbotten). Law of June 13, 1908 (Gottland). Law of June 15, 1923 (Forest in general). Law of June 15, 1923 (Forest conservation boards). Law of July 24, 1903 (Timber sale agreements). Law of October 11, 1912 (Forest conservation tax).

At the request of the board, the provincial government may restrict cutting in areas where reproduction is likely to be especially difficult or impossible, may require that seed trees be left, and may empower the board to prescribe measures for insuring reproduction. It may even require that the board's consent be obtained for any cutting, except for domestic use, and that the timber be marked by the county forester or other person designated by the board.

With the board's permission, forest land may be cleared for cultivation, pasture, buildings, etc., if the land is suitable for such use and if the area to be cleared is not unreasonably large.

Leases or timber-sale agreements may not be made for longer terms than 5 years.

A special law deals with protection forests, the preservation of which is necessary for protection against landslides and drifting sand. The King, upon recommendation of the local conservation board, may decree that no cutting shall be done in such forests, except for the domestic use of the owner, without a permit from a State forester. Further restrictions may be imposed if necessary. If an owner prefers to give up his land rather than submit to restriction on its use, the State is to buy it.

There are also special laws applicable to several of the individual provinces. In Vasterbotten and Norrbotten it is forbidden to cut coniferous trees for commercial use that are less than 21 centimeters (8.4 inches) in diameter inside bark, except where orderly management of the forest requires that such trees be cut. Even then a permit must be obtained from the local forester and he must mark the trees to be cut. The owner has to pay the forester for his time and expenses in making inspections, but not for the cost of marking. Forests may be cleared in order to cultivate the ground, erect buildings, etc., but the wood that is cut may not be sold except with the permission of the forester.

In Gottland, an owner may not cut any timber (except for his own use or to clear the land for cultivation) without the permission of the conservation board, which may prescribe measures to insure restocking. This permission is to be given only after inspection on the ground. The board may carry out reforestation measures at the owner's expense if he fails to do so. If necessary, the King, after a hearing by the county commissioners, may impose restrictions on grazing in order to protect young growth.

SWITZERLAND[46]

Less than one third of the forest area of Switzerland is privately owned, and the private forests are mostly in very small tracts. Few are over 200 hectares (500 acres) in extent. There are practically no important areas of private forest in the high mountain districts. Public regulation is based on the policy that the forest area of the country must not be diminished.

Although many of the cantons had laws regulating clearing of forest land, these were generally little enforced until severe floods in 1830 and subsequent years called attention to the protective value of forest cover. Later, the Federal Government made small grants toward reforestation and engineering works in the Alps. In 1876 a law was passed providing for Federal control over protection forests in the mountainous portions of certain cantons. In 1902 the Federal Government assumed general supervision over all the forests of the country, which were to be classified as protection forests and nonprotection forests. This classification was done by the cantonal authorities, subject to approval by the Federal council.

Protection forests were those in the reception basins of torrent and those affording protection against avalanches, falling rocks, landslides, soil washing, irregularities of stream flow, and harmful climatic influences. In 1914, 60.8 percent of all private forests were classed as protection forests. In 1923 nonprotection forests were put under restrictions similar to those governing protection forests.

Deforestation or even clear cutting is forbidden unless especially authorized (for nonprotection forests) by the cantonal or (for protection forests) by the Federal authorities. Where such permission is given, the authorities may require the afforestation of an equal area elsewhere. All cutting must be supervised by foresters. Cut-over areas, as well as openings caused by fire, avalanche (where possible to restock such areas), windstorms, etc., must be reforested within 3 years. Trees in wooded pastures must be conserved so far as possible.

The Federal Government or the cantons may require an owner to construct defensive works against avalanches and rock slides, and to establish protective forests where these are necessary to protect existing forests from damage. The confederation and the cantons pay a large part of the cost of such work. An owner may demand that the canton or commune purchase land on which the creation of a protective forest or defensive works has been ordered. The Federal Government contributes up to 50 percent of the purchase price for lands bought by the cantons or communes.

Where privately owned forests are in especially exposed situations or in the reception basins of torrents, the owners may be compelled to pool their forests so that they can be managed according to a common plan. The Federal Government pays the cost of organizing these combinations and the cantonal foresters are to supervise them without cost to the owners. The formation of similar associations may also be required in other places upon request of two thirds of the owners if they own more than one half of the forest land within the unit. The

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[46] Loi federale concernant la haute surveillance de la Confederation sur la police des forêts, du 11 Octobre 1902.

Fernow, B. E., A Brief History of Forestry, p. 191–197. Cambridge, Mass., 1911.

Paillié, M., "Rapport sur l'intervention de l'Etat dans la gestion des forêts particulières d'après quelques législations récentes. In Actes Congrès International de Sylviculture, p. 32–53. Internatl. Inst. Agr., Rome, 1926.

Petitmermet, M., manuscript report in files of U.S. Forest Service. 1931.

Federal Government (in some instances with additional grants by the cantons) contributes 30 to 50 percent of the cost of reforestation in protection forests where the opening is the result of fire, storm, avalanche, or insect epidemic, and also contribute up to 40 percent of the cost of logging roads and other facilities for transporting timber.

Most of the cantons have their own forest laws, which supplement the Federal law. Some of them are considerably more restrictive. In Berne, for instance, no forest may be cleared unless at least an equal area is planted. Grazing in the catchment basins of torrents is prohibited, and any forest grazing or gathering of litter is subject to strict supervision. Protection forests must be handled under working plans approved by the cantonal council, and their execution is supervised by the cantonal foresters. All cutting, except for household use, must be authorized in advance. In Vaud all trees over 15 centimeters (6 inches) in diameter that are to be cut must be marked. Any cutting removing more than 20 cubic meters per hectare (approximately 280 cubic feet per acre), or unduly breaking the canopy, must be authorized in advance, and the method of cutting may be prescribed in detail.

In Valais, for every cutting amounting to more than 5 cubic meters in high forest or 12 cubic meters in coppice, the trees must be marked with the assistance of a cantonal forester, and for commercial cutting in excess of 30 cubic meters of timber or 40 steres of cordwood the marking must be done by the forester. When clearing is allowed, the owner must reforest an equivalent area at his own expense. Grazing where the young growth is less than 4 meters high is forbidden. In Neufchâtel trees to be cut must be marked in company with an inspector. Clear cutting of more than 0.3 hectare in one place may not be done unless authorized by the Federal council.

TANGANYIKA [47]

The area of privately owned forests in Tanganyika is relatively small. Not more than one fourth of the area of any forest of more than 250 acres may be cleared unless reforestation is assured. The Conservator of Forests may control felling on lands situated on catchment basins where it appears that cutting of the timber would jeopardize water supplies. Private owners who manage their forests under working plans approved by the conservator are not subject to other restrictions.

TURKEY [48]

Less than 5 percent of the Turkish forest is privately owned. The forestry law of 1924 requires an owner to obtain a permit before cutting in his forest. Such permission may be refused unless he submits a plan of exploitation.

YUGOSLAVIA [49]

About one third of the forest area of Yugoslavia is in private ownership, mostly in small holdings. The forest legislation is based on the principle that the soil of the country, regardless of its nominal ownership, belongs to society, including all future generations, and that consequently it must not be utilized in such a way as to destroy or reduce its productivity. The owner has the right to dispose of the timber in any way he may see fit, provided he does not impair the continued productivity of the land or the protective effect of the forest in case of classified protection forests.

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[47] Proceedings of British Empire Forestry Conference, 1928, p. 80.

[48] Hinkle, E. M., Manuscript report in files of U.S. Forest Service. 1932.

[49] Loi sur les forêts, 21 decembre 1929. In Annuaire International de Legislation Agricole, 1930. Internatl. Inst. Agr., Rome, 1930.
Ugrenovic, Aleksander, Manuscript report in files of U.S. Forest Service. 1932.

Existing forest must be conserved. Land that is essentially forest land (because of soil, topography, and location) may be cleared only for building roads, reservoirs, or other construction. The clearing of other forest land may be authorized where it will be put to better use, without injury to other parties. Local administrative officials may authorize clearings of less than 5 hectares; larger ones are passed upon by the governor of the province. Management plans must be submitted for forests of over 300 hectares, and every forest enterprise with an annual output of over 30,000 cubic meters of hardwood or 50,000 cubic meters of softwood is required to employ a qualified forester, who must be a Yugoslav citizen.

Forest devastation is forbidden, as is any practice that will impoverish the soil or endanger its continuous productivity. Cut-over land must be reforested within three years and land denuded prior to adoption of the law (1930) within five years, according to methods prescribed by the authorities. If an owner fails to do this, it is to be done at his expense.

Every owner must take care, in cutting his forest, not to expose neighboring forests to damage from wind. He may be required to leave a protection strip as wide as twice the height of the neighboring trees. Owners must use all reasonable means to combat disease or insect epidemics, and must notify the authorities immediately of their outbreak. Forests may not be grazed so as to injure the young growth. Livestock must be in charge of a herder, must use designated roads in going to and from the range, and must be kept in corrals between sunset and sunrise. Goats are not to be allowed in forests, with certain exceptions. Methods of utilizing dead litter and green foliage (for fodder) are also subject to restriction, as is the use of fire in or near forests.

Private forests may be divided only with the consent of the proper authorities, who may refuse permission when the division seems likely to jeopardize continuity of production. Two thirds of the owners of forests within a natural unit, if they own at least two thirds (by value) of the land, may form a cooperative association for purposes of protecting and managing the forests, and other owners within the unit may be required to join.

Protection forests are to be designated by the governor in each province, either upon his own initiative or upon request by interested parties, and after examination by forestry experts. Permanent protection forests are those protecting the soil from sliding, blowing, or washing; those protecting springs or preventing rapid run-off or avalanches, and those near timber line. Temporary protection forests are those serving as windbreaks, etc. Forests serving purposes of national defense may be either permanently or temporarily classified. Clear cutting in protection forests is forbidden, and the Minister of Forests and Mines may prescribe measures essential to maintain the protective effect of the forest. In case these restrictions exceed those necessary to prevent devastation the property is to be partly or wholly exempted from taxation. If the restrictions are so onerous as to cause serious loss to the owner he may require that those who are benefited buy the forest. All protection forests must be managed under approved working plans, prepared by graduate foresters who are Yugoslav citizens. These plans are to be based on continuous forest production, but not necessarily on the principle of sustained yield.

Land which is not now forested, but which is suitable for forest growth and should be forested in order to protect the soil, prevent silting, or promote health, etc., is also to be classified as protection forest by a special commission in each province. Afforestation of such land must be undertaken promptly and completed within 50 years. The State is to cooperate by providing planting stock and supervision, and by granting tax exemptions, cash subsidies, and non-interest-bearing loans.

ESSENTIAL FEATURES OF FOREIGN CONTROL POLICIES

The policies of the various countries differ widely as to both the degree and the method of public control over private forests. Certain fundamentals, however, are common to many of them. Most of the world has come to the conclusion that forests should be preserved, and that this will require public action. Hiley has stated the situation concisely, as follows:

> It may be accepted as a generalization that private or commercial ownership of forests, when unfettered by legislative restriction, generally leads to devastation * * *. The accepted solution of the problem is some form of state intervention, and state control of forests is now practiced in nearly every civilized country in the world.[50]

The essential features of a composite policy, which might be built up from the most generally accepted principles of the many different policies described above, may be summarized as follows:

1. As a general principle, an owner is free to manage and utilize his forest as he pleases, so long as such use does not directly or indirectly injure other individuals or the public welfare.

2. Destruction or mismanagement of forests which serve to hold the soil in place, conserve water, regulate the flow of streams, protect the public health, or promote the national defense is certain to result in injury to others. The public exercises a sufficient degree of control over this class of forests to insure that their protective functions are not jeopardized. This involves the maintenance of a continuous forest cover. It frequently involves the execution of reforestation or engineering improvement works, or even the afforestation of hitherto nonwooded land, either by public agencies or by the owner. Except where reforestation is made necessary by act of the owner the public pays part or all of the cost. The public usually indemnifies the owner for any loss of income resulting from restrictions on the use of protection forests. As an alternative the public may acquire the land, either at the owner's request or by condemantion.

3. Protection forests are classified as such by a commission or by some high governmental agency, upon the recommendation of some public body or upon application of interested individuals or groups, and after appropriate investigation and hearings. The forest service

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[50] Hiley, W. E., The Economics of Forestry. 256 p. Oxford University Press, 1930.

or other agency responsible for enforcing the law may initiate the classification and may be required to make the field examination and report its recommendations, but it generally does not have the power to render the final decision as to classification.

4. Cutting in classified protection forests may be done only with permission of the competent authorities. The methods of cutting and of utilizing the forage and other products which may be allowed in such forests are specified in some detail either in the law or in regulations of the supervisory authority. Reforestation of cut-over areas is compulsory. Management plans and employment of trained foresters may be required but generally are more or less optional. An owner handling his forest according to an approved plan and under the supervision of a trained forester is not required to get a special permit for each operation.

5. Gross misuse which destroys or seriously impairs the productivity of the land is generally assumed to be inimical to the public welfare. The object of control over other than protection forests is generally not to compel owners to produce any particular kind or quantity of material, but to insure that the land will be kept in a productive condition. Sustained yield management is usually not required, and control over methods of management and utilization is reduced to a minimum. A permit is usually required for deforestation, but it is granted if the land is suitable for other use and will be utilized productively. Otherwise, reforestation by natural or artificial means is required. Working plans are usually optional with the owner, and are primarily for his own protection or convenience. Although the public exercises or holds in the background definite mandatory powers to prevent destruction of nonprotection forests, it attempts to bring about good management largely through educating and cooperating with the owners.

6. Public control in many countries is democratized and decentralized by being put under the general supervision of local or provincial boards or commissions on which forest owners, technicians, and administrative officials, and in some instances the local population, are represented. A few countries, mostly small ones, have only one central commission for the entire country. In some countries these boards have their own administrative and inspection forces and work independently of the state forest service. In other countries the boards exercise general supervision but actual administration is by officers of the state forest services.

IS FURTHER PUBLIC REGULATION DESIRABLE IN THE UNITED STATES

PRACTICES IN NEED OF CORRECTION

In order to determine whether further public control over private forests in the United States may be desirable, it is necessary first to inquire what controllable conditions or practices threaten to destroy the forests, to hinder or prevent their replacement after cutting, or to render them less productive. These may be classified as follows:

(1) Failure to provide effective protection against fire, as well as practices which cause fires directly or which increase the fire hazard, and also the failure to adopt reasonable measures for preventing and suppressing fires.

(2) Neglect of reasonable measures for preventing or checking attacks of diseases and insects, and also those practices which favor the spread of destructive pests.

(3) Destructive exploitation. That exploitation is destructive which (*a*) destroys potentially usable timber without using it; (*b*) renders natural reproduction of good species uncertain or impossible (unless the operation is followed promptly by effective artificial reforestation); (*c*) depletes the growing stock in quantity or quality so that the forests of an economic unit are incapable of maintaining a continuous production; or (*d*) increases unnecessarily the hazard from fire, insects, diseases, and storms for either the remaining or the succeeding stand or for neighboring forests.

(4) Clearing of forest land not needed for agriculture or other use, where the physical and economic conditions are so unfavorable to such use that abandonment and reversion to a state of idleness are fairly certain.

(5) Improper silvicultural practices, resulting in unsatisfactory stocking, reduction in yields, and in the productive capacity of the soil, deterioration in quality of the product and reduction in net income.

It is desirable that all of the above practices be checked or corrected. It probably is not desirable and certainly is not practical at the present time, to correct all of them through mandatory regulation by public agencies.

PRACTICES TO WHICH OPTIONAL REGULATION MIGHT APPLY

Up to a certain point, the right of the public to exercise mandatory control is generally recognized, at least in theory. Beyond that point, depending on local conditions, regulation will be feasible only if it is acceptable to the owners and shared by them. As has been pointed out, the public can compel individuals to desist from practices which will result in direct injury to other individuals or to the public. The right of the public to interfere for the purpose of maintaining the yields of private forests at a high level is less well established.

Practices which are undesirable chiefly because they reduce the owner's income and depreciate the value of his property include the following:

(1) Premature cutting of immature or economically unripe timber of desirable species and quality, especially where this is done at a loss.

(2) Wasteful methods in woods and mills.

(3) Premature turpentining of timber that is too small, and turpentining methods leading to waste of the timber.

(4) Improper or inefficient silvicultural practices, such as:

(a) Choice of species not suited to the site.

(b) Carelessness as to the source of seed for raising planting stock, resulting in the use of races ill-adapted to the site.

(c) Adoption of too short rotations, leading to deterioration of the site, difficulty of natural reproduction, and production of inferior material.

(d) Reliance on coppice rather than seed to establish the new stand.

(e) Failure to maintain the optimum density of stand, or to thin and weed as necessary.

(f) Failure to reforest or afforest bare areas resulting from earlier logging, fires, etc.

(g) Failure to maintain a suitable mixture of species so as to maintain the fertility of the site and take full advantage of its productive capacity.

(h) Culling the best trees, thus leaving inferior and defective individuals as a growing stock.

(i) Failure to cut old decadent and defective trees which are hindering the growth of valuable individuals.

(5) Cutting of timber (except where desirable to reduce surplus growing stock) in excess of the annual increment of the unit.

Desirable standards with regard to these practices cannot be attained through restrictive legislation, unless the owners voluntarily consent to public control. About all that the public can do is to attempt to persuade them to adopt desirable practices. This can be accomplished in part through systematic suggestion, education, and demonstration. In some instances, however, forest owners will readily accept a certain degree of restriction in return for assistance by the public. In view of the public benefit that would result from the better handling of forests in general, it is appropriate for the public to help individual owners or associations of owners in improving their practices, providing the owners will submit to restrictions which will safeguard the public interest.

PUBLIC AID AS BASIS FOR OPTIONAL REGULATION

Such assistance may take the following forms, all of which have been tried in foreign countries, and several of them in the United States, as discussed in other sections of this report:

(1) Management of the forest for the owner, to such extent and with such division of the costs as may be agreed upon.

(2) Grant of free or low-cost planting stock and other material.

(3) Tax concessions or adjustments of various sorts intended to lighten the financial burden on the owner.

(4) Loans or other credits on favorable terms, sponsored by public agencies.

(5) Concessions in public forests, providing for integrated sustained yield management under some degree of public control.

(6) Public insurance against fire and other loss, or some form of assistance in establishing a working system of private insurance.

(7) Outright subsidy, for certain specified operations or practices.

(8) Assistance in construction of roads and other means of exploiting the forests efficiently on a permanent basis.

(9) Assistance in preventing and combatting fires and fungus and insect pests.

Public aid will not be justified merely for the purpose of benefiting individual forest owners. It will be justified only if benefit to the public will result. It should not be regarded as a bonus or gift to forest owners, but as a payment for which value will be received by the public. So far as practicable, grants of public aid should be contingent upon acceptance of restrictions which will insure that the value will be received. In short, private forest owners should not be favored with special privileges or services at the expense of the public treasury, unless they assume corresponding obligations with respect to the handling of their forests.

OPTIONAL REGULATION THROUGH ASSOCIATIONS

One other form of control which has been proposed recently is control through organizations of forest industries or forest owners. From the standpoint of the public, there can be no legitimate objection to voluntary association or combination of owners and/or operators for the purpose of bringing about desirable ends which they cannot accomplish independently. Such objectives, for instance, might be protection against fire or insect epidemics, or adoption of sustained yield management in a unit where holdings are comparatively small or intermingled or for other reasons not capable of management as independent units. The laws of some countries seek to promote the formation of associations for these purposes, particularly among the owners of small and medium-sized tracts. In this country several States provide for associations for protection against fires and insects.

In order for such combinations to accomplish their purpose, it might be necessary to provide some way by which owners who will not conform voluntarily to the policies of the group would be compelled to do so. Whether a State can legally, or would if it could, grant authority to associations or combinations of individuals to compel action by other individuals is doubtful. It is not likely that the State would either delegate its police powers to private individuals or associations, or sanction enforcement through "unfair" methods of competition. It must follow, then, if there is to be any compulsion of unwilling owners, that it will have to be exercised by public agencies. It is fairly certain that such authority will not be exercised unless to enforce policies which are clearly in the public interest—those making for the stability of industries, communities, employment, and public revenues; for the conservation of natural or human resources; or to protect the interests of consumers.

There is no doubt that the Federal Government has the authority to enforce compliance with a program for organized fire protection, or even for the regulation of cutting, where preservation of the forest is necessary for purposes of national defense, to prevent damage to lands or other property of the Federal Government, to maintain the navigability of streams and harbors, or to prevent damage to persons or property beyond the borders of the State. The authority of the States, at least, undoubtedly goes further than this. It might be feasible for State law to provide that when most of the owners—perhaps two thirds or three fourths, in consultation with a suitable public agency—agree upon certain practices as desirable or necessary to safeguard or promote the public interest, the remaining owners may be required to fall in line, at least to the extent that they do not obstruct the program of the group. If such a policy should be adopted, it would also be necessary to provide that where owners refuse or are unable to conform with the prescribed program their land may be expropriated, either permanently or temporarily, after due compensation.

PRACTICES WHICH MIGHT PROPERLY BE SUBJECT TO MANDATORY REGULATION

Obviously, the simplest way to insure the correction of harmful practices would be for the public to acquire all of the forest which affects the public interest. But even if the public should embark on a large-scale program of acquisition, it would probably take a very long time to get all of the forest that should be acquired. Meanwhile, if there are no restrictions on the utilization and management of the forests, present practices may be continued, with irreparable injury to the forests themselves, to their owners, and to the public. Whether or not the eventual solution is to be public ownership of virtually the entire forest area, some means should be found to protect the public interest as long as the forests remain in private ownership. Much can be accomplished through public assistance to and cooperation with private owners. There is nothing in the experience of this or any other country, however, to give grounds for confidence that voluntary cooperation will sufficiently safeguard the forests.

From the standpoint of public policy, there can be no valid objection, in principle, to such degree of public control over private property as may be necessary to prevent injury to other individuals or to the public in general. This principle is thoroughly established in the laws of every State. That it applies to forest property as well as to every other kind of property is admitted by spokesmen of the forest owners, even though they may question the advisability of regulation which goes beyond this. To quote two of them:

> The States * * * can and should make drastic regulations to prevent forest fires. * * * Every owner of forest land (should) be required to conduct operations thereon in such a manner as to avoid creating a fire menace to adjacent property.[51]
>
> Like every other owner of property, the owner of forest land is bound in law so to use his property as to do no harm to the property of another, and to do no public injury. This obligation is universal, is everywhere recognized, and should be enforced.[52]

The application of this principle to forest property has been clearly upheld by the Supreme Court of Maine. That court ruled that the State may regulate cutting or destruction of trees growing upon privately owned land, for the purpose of promoting "the common welfare by preventing or diminishing injurious droughts and freshets, and by protecting, preserving, and maintaining the natural water supply of the springs, streams, ponds and lakes and of the lands, and by preventing or diminishing injurious erosion of the land and the filling up of the rivers, ponds and lakes." One of the principal reasons which the court gave for reaching its decision is stated as follows:

> The amount of land being incapable of increase, if the owners of large tracts can waste them at will without State restriction, the State and its people may be helplessly impoverished and one great purpose of government defeated.[53]

PREVENTION OF DIRECT INJURY TO OTHERS

That mandatory or compulsory control is logical public policy is shown by the fact that it is already provided for, in varying degree, by the laws of several States with respect to those practices which threaten direct injury to other persons or the general welfare. These practices include:

(1) Practices which increase the danger from fire, such as (*a*) carelessness with fire in connection with timber-cutting operations or

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[51] R. S. Kellogg, in Journal of Forestry 19: 641–646. (October 1921.)
[52] Wilson Compton, in Journal of Forestry 18: 258. (March 1920.)
[53] See Seventh Report of the Forest Commissioner of the State of Maine. 1908. pp. 30–35.

other use of the land; (*b*) failure to provide and, if necessary, to use suitable safeguards and fire-fighting equipment in connection with operations (firebreaks, spark arresters, tools, etc.); (*c*) increasing the fire hazard through creating or leaving dangerous accumulations of slash, standing snags, or other inflammable material, or through clear cutting over too large areas; (*d*) failure to control fires, no matter how they start, so as to prevent their escape to another's land.

(2) Practices which increase the danger of damage by diseases and insects, including (*a*) creation of breeding places through leaving accumulations of slash, or leaving unpeeled logs in the woods under certain conditions; (*b*) failure to carry out such sanitary measures, within reasonable limits, as may be necessary to check the spread of insects or diseases.

(3) Practices which increase the danger from windthrow to the adjacent forests of other owners. This frequently results from clear cutting close to the boundary lines of the property.

PROTECTION OF WATERSHED VALUES

According to another section of this report ("Watershed and Related Forest Influences"), some 300 million acres of forest land now in private ownership has great public value for purposes of protecting watersheds, preventing erosion or landslides, and for related purposes. Large areas of other land that was cleared in the past have eroded so badly after a brief period of cultivation that they can no longer be used unless reforested. In the section on "Current Forest Devastation and Deterioration" it is estimated that some 850,000 acres a year of privately owned commercial forest land is being devastated, chiefly as a result of fires following cutting. Probably 300,000 to 350,000 acres of this is so located as to have high value for protective purposes. For this class of forest, mandatory regulation might legitimately go much farther, and might extend to any practices which will destroy or seriously impair the protective value of the forest, such as:

Methods of logging which tend unnecessarily to destroy or damage immature timber and young growth.

Clear cutting of large areas on sites where exposure to sun and wind will result in site deterioration, erosion of the soil, or increased danger from fire; especially clear cutting on steep slopes.

Failure to leave suitable seed trees or to provide otherwise for prompt restocking by natural or artificial means.

Overgrazing, resulting in injury to or elimination of young growth, destruction of protective ground cover, deterioration of the site, or erosion; especially on reproduction areas.

Clearing of land (deforestation) either to put it to other use or to leave it in a state of denuded idleness.

FURTHER MANDATORY REGULATION

It can be argued that mandatory regulation should go much farther than this. It can hardly be denied that devastation of his own land by a forest owner, even where watershed and soil protection are not involved, results in loss to the community, State, and Nation. It not only impoverishes existing communities, but it also reduces the sum total of natural resources available for future generations. Anyone who has seen the wrecked landscapes and man-made deserts which have followed the exploitation of forests in some of the flat lands of the Lake States or the southeastern coastal plain will readily admit that the public welfare has been adversely affected. It is unthinkable that the public should be helpless to protect itself against such waste, or should have to wait and repair the damage after it has been done instead of preventing it. However, if fires can be held in check the most serious cause of forest devastation and deterioration will have been eliminated, and nature will grow a new crop of timber on most of the land that is cut over in the future, as well as on much of that already cut over.

Mandatory regulation beyond that sufficient to hold fires and pests in check, and in the case of protection forests, to maintain a forest cover, might be too drastic for the American people for a long time to come. Even if laws providing for a greater degree of regulation were adopted, they would undoubtedly be difficult to enforce. Attempts to enforce them would very likely jeopardize the effectiveness of more moderate and reasonable forms of regulation. It should also be recognized that general mandatory regulation, even of protection forests, is not likely to be adopted overnight, either by the Federal Goverment or by any considerable number of States. This will have to come about gradually. Quite possibly, however, it may come more rapidly than was the case with the modest degree of regulation now in effect with respect to the control of fire. The cumulative effects of the mistreatment of forests and forest land are becoming more and more evident. As soon as the public demonstrates its readiness to help them by assuming its equitable share of the cost of maintaining protection forests, forest owners will be less likely to object to reasonable restrictions.

ELEMENTS OF A POSSIBLE PUBLIC REGULATION POLICY

If it should be decided to go farther than existing laws in the direction of public regulation, there are several principles which might well be taken into account in formulating policies.

In the beginning, at least, public mandatory regulation should be confined to those things that are clearly the most essential and which the public most unquestionably has the right to demand for its own protection. Specific recommendations on this point are discussed in a later chapter of this report. (Section on "A Possible Program for Public Regulation" in the chapter on "The National Programs Required.") The regulatory laws should be simple and their scope clearly defined. They should provide that forest owners or their representatives be consulted in the formulation and execution of enforcement regulations.

On its part, the public should fulfill its responsibilities in protecting the owners against injury for which they are in no way to blame, such as fires originating on outside land or from causes beyond their control. It is desirable also that the public go a long way in helping forest owners to carry out a positive, constructive program, that is, to do more than merely prevent the destruction of their own or neighboring forests. The question of public assistance to private owners is discussed under the headings "Federal and State Aid" in other sections of this report. In some instances, such assistance might well be contingent upon a still further degree of public control. This might be the case where acceptance of aid, and consequently of control, is optional with the owners. It is only reasonable that the public should pay for measures aimed primarily at benefiting the public rather than the individual owners. The principle should be maintained from the outset, however, that a private owner is neither morally nor legally entitled to any reward or compensation for obeying such restrictions as may be necessary to prevent injury to other individuals or the public.

Because of constitutional limitations upon the powers of the Federal, State, and local governments, no uniform method of public control can be applied to all private forests in the United States. Control may be exercised under certain conditions by the Federal Government. Under certain other conditions the States unquestionably have the necessary authority to do what the Federal Government cannot do. For these reasons a comprehensive policy would embrace three forms of control: (*a*) Mandatory control by the Federal Government; (*b*) mandatory control by the States and/or subdivisions of States, such as counties, municipalities, or forest districts; (*c*) public or cooperative control at the option of the owners themselves. Certain combinations of the three might be desirable; for instance, the Federal Government might assist the States financially and otherwise to carry out control under State laws, just as is being done now in fire protection. The division of responsiblity for the exercise of control is discussed in another section of this report.

In cases where no legitimate form of control or voluntary action under private ownership can be relied upon to maintain the forest in the condition required by the public interest, provision should be made for expropriation, with due compensation, by Federal, State, or local authorities. This step should be taken before the forest is destroyed, for rehabilitation of devastated forests will require many years and is likely to be much more costly in the long run than acquisition of the existing forest.

OBSTACLES TO MANDATORY REGULATION

ANTAGONISM OF FOREST OWNERS

As has been shown, the right of the public to protect its own interests and those of individuals by restrictions upon the use of private property has sound legal basis and is freely acknowledged, in principle. Nevertheless, aversion to outside control over one's own actions is deeply ingrained in human nature. In part, objection to public control is purely selfish. In part, however, it is due to a sincere fear that control would be abused: that it would be unreasonable, would not stop where it properly should stop, or would give some individuals an unfair advantage over others. Opposition on the grounds that it would cost the taxpayers money or that it would involve an extension of bureaucracy is largely specious or due to a lack of understanding as to just what public regulation might involve.

If public control were really believed desirable or necessary, no reasonable person would object to a reasonable cost or to the setting up of the requisite enforcement organization. As was pointed out in the sections "Is Forestry Justified?" and "Watershed and Related Forest Influences," the devastation of forests has cost the taxpayers a great deal more than any system of regulation likely to be proposed. Moreover, the enforcement of fire laws and restrictions on denudation of forest cover, even when coupled with such contributions toward protection and management as the public should equitably make, is bound to cost less, at least during the next few decades, than public purchase and management of the entire forest area.

In the case of forests, the fear of bureaucratic control may be attributed in part to the vagueness which has enshrouded most of the discussion of the subject. With some degree of justification, many have assumed that a public agency would be empowered to specify in detail how an owner may manage his land and cut his timber, and would be given a free hand to try out all sorts of silvicultural fads at the owner's expense. If this were to be the case, there would be good reason to shudder at the extension of bureaucracy. Silviculture is not an exact science, and it is impossible to standardize methods of handling forests under the great diversity of conditions which exist. No public agency (or private, for that matter) is wise enough to dictate the specific methods to be followed by forest owners. Such dictation is neither necessary nor desirable. All of the regulation that is necessary to protect the public interests can be accomplished without it. As a general thing, it should be necessary to interfere with an owner's management of his forest only when his practices are prejudicial to the public interests.

Where the proposals for public regulation have been definite and obviously reasonable, there has been less opposition. For example, there is little opposition now to restrictions on the use of fire during danger seasons, or on the careless use of fire in general. Such requirements are incorporated in the laws of most States, and have the backing of a considerable body of public opinion.

Likewise, there is not much opposition in principle to requiring such disposal of logging slash as may be necessary to obviate undue hazard to neighboring property. There is more opposition in practice, however. Slash disposal may be costly. Operators are not anxious to spend any more than is absolutely necessary to reduce the fire hazard, since from the individual point of view this appears to be an unproductive outlay. Naturally, it is feared that the public agencies responsible for enforcing the requirements may insist on more intensive and costly measures than are really necessary. There is some ground for this feeling, because the underlying principles and the technique are not yet thoroughly understood, even by foresters. Many States have enacted laws dealing with the disposal of slash, and the necessity of adequate slash disposal is fairly well recognized in most forest regions, but there is still difference of opinion as to what the requirements should consist of and how they should be determined.

PUBLIC INDIFFERENCE

The opposition of persons who would be subject to regulation is passively supported by the indifference of the general public, which has not realized that mistreatment of forest lands has any particular effect on its own interests. These two factors combined constitute the greatest practical difficulty confronting a policy of public regulation. Until they can be in a large measure overcome, it will be difficult to get adequate regulatory laws adopted, or to enforce the laws that may be adopted.

CONTROVERSY OVER JURISDICTION

Another thing which has confused the issue is the controversy as to whether control should be exercised by the Federal Government or by the States. This is a very important problem when it comes to the application of public control. It is discussed in the section of this report which deals with The National Programs and the Responsibility for Them. It should not be allowed to obscure the fundamental question, namely, whether any public agency should exercise any control over the use of private forests.

SUMMARY OF ARGUMENTS AGAINST AND FOR PUBLIC REGULATION IN THE UNITED STATES

Various arguments have been or may be advanced in opposition to a policy of public regulation. The principal ones, together with the corresponding arguments in favor of regulation, are briefly as follows:

1. *Against regulation.*—Regulation is not necessary, because we shall not need forests in the future. This argument is based primarily on misgivings as to future timber requirements.

For regulation.—Other sections of this report have shown that the maintenance of forests is of great public concern, not only to supply useful and essential raw materials, but also because of the other, frequently more important, public values of forests. The conservation of forests is an established public policy in nearly all civilized countries. In the United States this policy is recognized both by the Federal Government and by the States through legislation and large expenditures of public funds for maintenance of public forests, for protection of privately owned forests against fire and other damage, for encouragement of forest planting by private owners, and for forest research, education, and extension work. It is also recognized through special forest taxation legislation in many States.

2. *Against regulation.*—Regulation is not necessary, because private owners, in pursuing their individual self-interest, can be depended on to handle their forests in such a manner as to serve the public interest. That this has not generally been the case in the past was because the public put obstacles in their way, or did not do its share in removing existing obstacles.

For regulation.—The public welfare has suffered, and is still suffering, great and well-nigh irreparable injury as a result of the destruction and deterioration of forests under a policy of unrestricted freedom of private action. Even if the public should do all that it legitimately could in helping forest owners, there would be no assurance that every owner would handle his forest in the public interest. Regulation would impose restrictions only on those who proposed to act contrary to the public interest.

3. *Against regulation.*—For the public to interfere in the management of privately owned forests would be a radical invasion of the rights of private property, contrary to our traditional policy.

For regulation.—It has been shown in the preceding pages that for the public to regulate the use of private property in order to protect and promote the public welfare does not involve any new or untried principle. On the contrary, this policy is firmly established in the legislation of this and other countries. Instead of being an unwarranted invasion of private property rights, it is necessary for the defense of private property as well as the public welfare. The destructive practices of some owners make it difficult for other owners, who would like to handle their forests conservatively, to do so.

4. *Against regulation.*—A policy of public regulation would necessitate an army of public employees and bureaucrats whose meddlesome interference would stifle private enterprise.

For regulation.—No large number of public employees would be necessary. Regulation can and should be decentralized, and the owners should have a share in it. Owners who follow good practices would not be interfered with. There need be no attempt to dictate details of management.

5. *Against regulation.*—Regulation would mean further Federal encroachment on the authority and responsibilities of the States.

For regulation.—Regulation need not be centralized. Where only State or local interests are involved, the States would naturally decide upon their own policies of regulation, without interference from the Federal Government. Direct Federal regulation would logically be confined to cases involving national or interstate interests, where these will not be protected by State or local action. Even in these cases, there is no reason why Federal authorities should not cooperate closely with the State authorities. If the State laws and their enforcement in any State should be adequate to protect the Federal interests, Federal interference would not be necessary.

6. *Against regulation.*—Forest owners cannot afford to adopt the measures that might be required of them.

For regulation.—To the extent that restrictions consist merely of prohibition of acts that will cause direct harm to others, the cost to the owner of abstaining from such acts is not a legitimate consideration. This is a long-established principle of law. Restrictions that go beyond this, which will not bring an offsetting benefit to the owner, would be justified only if the public bears the expense.

7. *Against regulation.*—The cost of regulation would add greatly to the burden of the taxpayers.

For regulation.—Devastation and deterioration of our forests has been exceedingly costly to taxpayers, both through the loss of industries and shrinkage of the tax base in forested regions and through the cost of remedial measures such as flood control works and dredging of silt from rivers and harbors. In comparison with these costs, the cost of regulation would be ridiculously small, even when coupled with greatly expanded public assistance in forest protection and development. At least for the next few decades it would be cheaper for the public to prevent further forest devastation by means of suitable restrictions upon the acts of the owners than to acquire and rehabilitate a major portion of the forest land after the forest cover has been destroyed.

8. *Against regulation.*—Existing regulation, though mild in scope, is not well enforced in most States and is not particularly effective.

For regulation.—Existing regulation has not had a fair chance to become fully effective. Much of it is relatively new, forest owners in many instances are not aware that the laws exist, and adequate funds and personnel have not been provided for enforcing them. Moreover, the public has not always done its part in helping forest owners.

9. *Against regulation.*—Regulation would not be effective because of the antagonism of forest owners.

For regulation.—As explained above, part of the antagonism to the idea of regulation is due to a misconception as to what regulation would involve. Other sturdy individualists object because of a disinclination to allow a public agency or anyone else to tell them how to run their business. The newer generation of forest owners, however, has a better understanding of the evil results of unrestricted private exploitation than their predecessors had. If the public will do its part, it is not fantastic to believe that many owners will accept and even welcome a reasonable degree of restriction, providing it is applied impartially to all owners. As soon as a large proportion of forest owners, or of the more influential owners, can be made to see that a certain amount of restriction would be for the best interest of all and would not involve excessive interference with private business, such regulation can be effective. Regulation of a considerably more intensive character than might be desirable at the present time in the United States was quickly accepted by the forest owners and has been very effective in Norway, Sweden, and Finland.

10. *Against regulation.*—Public opinion is indifferent. Without the support of an informed public opinion, regulation would not be practical.

For regulation.—The public is rapidly becoming cognizant of the desirability of forest preservation. The damage done by forest fires is much better understood than it was. Events of the last few years have brought the dangers of floods and erosion prominently to public attention. The value of forests for recreation is appreciated as never before. The old idea that practically all land is suitable for agriculture is now pretty well exploded and it is more evident than formerly that a considerable area of forest land will have to remain in forest if it is to produce anything. Even forest owners are beginning to realize that devastation of most forests is unprofitable and economically foolish.

11. *Against regulation.*—Instead of trying to regulate private owners, the public should buy, or acquire by other means, all of the forest land.

For regulation.—Land acquired through tax default or through gift is likely to have had its productive and protective values seriously impaired before the public gets it. Purchase of the major portion of the still productive land would certainly be costly, and even if such a program could be agreed upon it would require many years for completion. Some provision should be made to prevent devastation of such land during the interim before it is acquired by the public. Moreover, under the most ambitious plan of public acquisition that is likely to be adopted, so far as can be foreseen at this time, a very large area of forest land will remain in private ownership.

CONCLUSION

Existing control does not go far enough to protect the present or future generations. It is to be expected that proposals for more adequate enforcement of existing legislation, as well as for further requirements, will meet with opposition and indifference. However, this is no reason for dropping public regulation as one of the essential means for insuring that our forest resources will be perpetuated and handled so as to promote the public welfare. On the contrary, every effort should be made to obtain the backing of public opinion, including the forest owners, for adequate regulation.

To do this will involve a continuous process of education regarding the importance of forests to the welfare of individual citizens and of the public as a whole. It should be made clear, particularly to forest owners, that such regulation as is proposed will not unduly interfere in the handling of their property, and that in the long run it will be to their advantage through preserving property values and extending the life of forest industries. As soon as practicable, regulation based on the principles outlined above should be adopted as a public policy. Specific suggestions for a program of public regulation of private forests in the United States are given under the heading "A Possible Program for Public Regulation" in a later part of this report (The National Programs Required and the Responsibility for Them).

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